

Comparison of Electroactive Polymer (EAP) Types:

Properties	Dielectric Electrostrictive EAP	Ion-exchange EAP	IPMC EAP
Relative speed of full cycle	≤Sec.	Minutes	Seconds
Maximum strain	100%+	Low	Moderate
Maximum efficiency	80%+	≤50%	≤50%
Operating voltage	3 to 7kV-DC	Few volts (3 to 24VDC)	Few volts (3 to 24VDC)
operating current	Micro amp.	Micro amp	Micro amp.
operating environment	Dry/Wet	Electrolyte media	Dry/Wet
Load displacement	Significant	Small	Moderate

Table A

FIG. 1

EAP Material Requirement

Following table lists some of the material requirement for the Electroactive polymer (EAP)
for the use as assist device and use as assist pump:

Description	Dielectric electrostrictive EAP	Ion exchange polymer metal composite
1. Base material	Silicone, Polyurethane, Latex, Styrene, Copolymers of styrene - like styrene-butadiene-styrene, Isoprene, Acrylate etc.	Ionomers like perfluorosulfonate and perfluorocarboxylate; Polyvinylidene fluoride, etc.
2. Elongation at break	600 to 1600%	50 to 500%
3. Tensile strength	2 to 60MPa	10 to 75MPa
4. Ionic conductivity	n/a	20 to 100 Volts/cm
5. Dielectric strength	1kV to 10kV per mil.	n/a
6. Hardness	3 to 50A	10 to 75A
7. Working voltage	500V to 10kV	1V to 48V
8. Working current	Micro Amp to Amp	Micro Amp to Amp
9. Electrode material	Conductive carbon, graphite, platinum, gold and silver	Conductive carbon, graphite, platinum, gold and silver
10. Electrode conductivity	Kilo-Ohm to mega-Ohm	n/a
11. Electrode placement	Conductive layer on the surface	Impregnated in the base material

Table B

FIG. 2

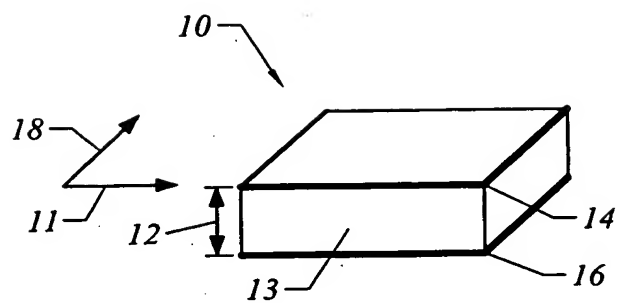


FIG. 3A

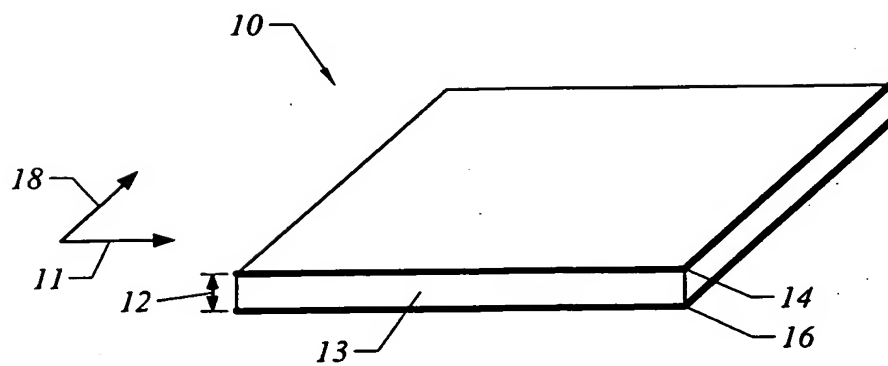


FIG. 3B

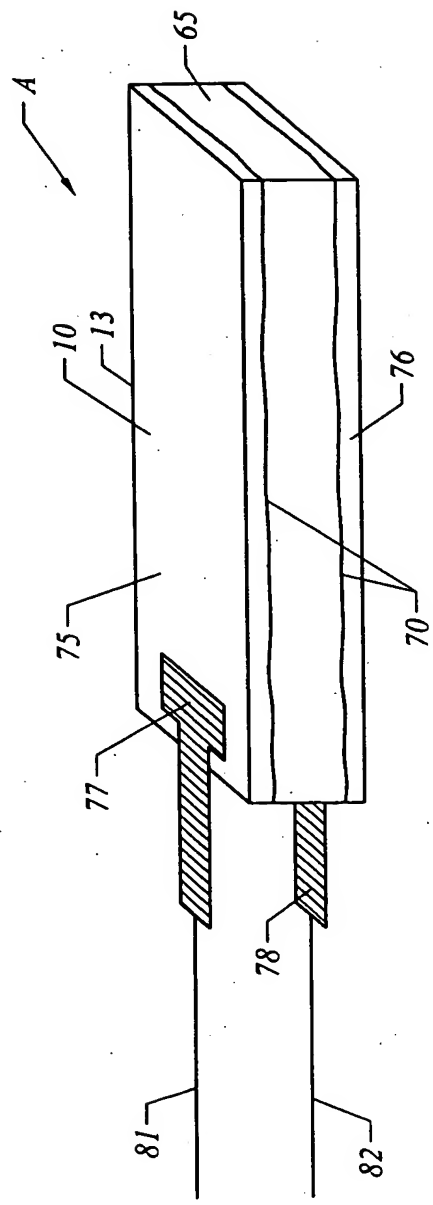


FIG. 4

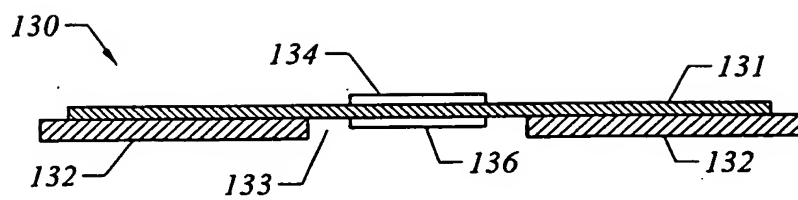


FIG. 5A

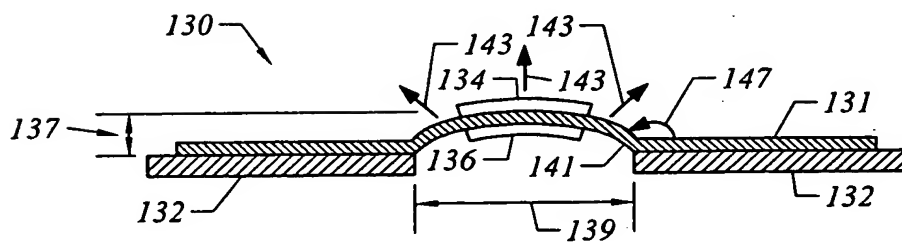


FIG. 5B

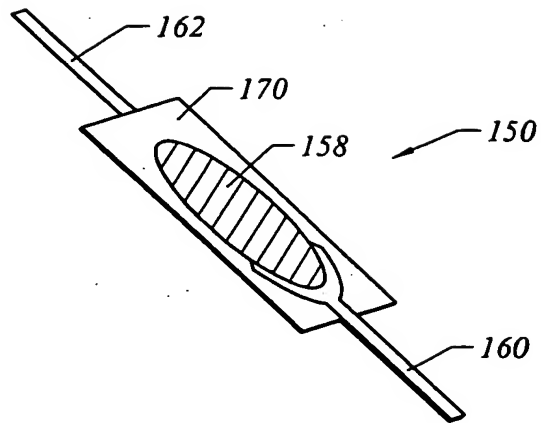


FIG. 6A

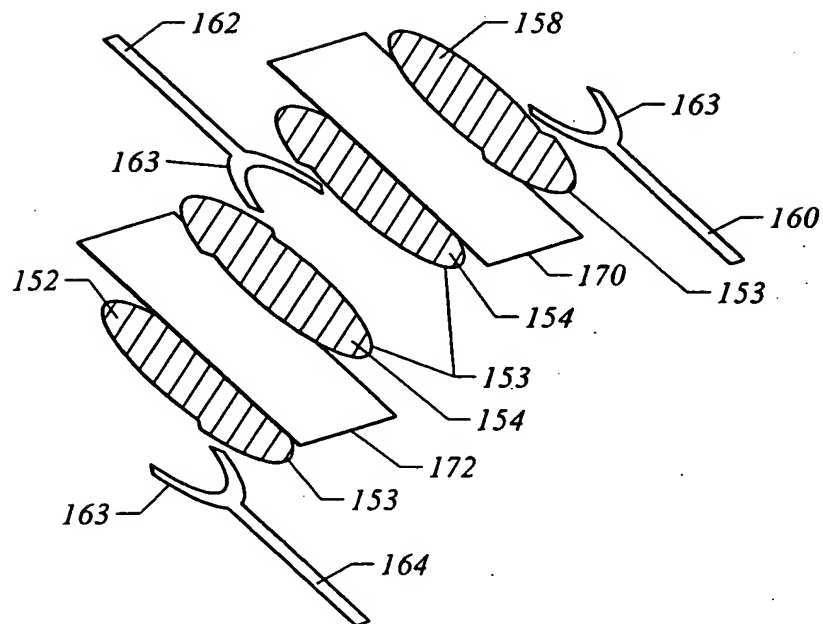


FIG. 6B

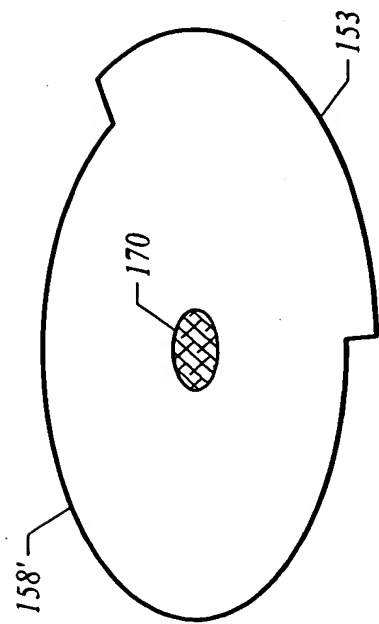


FIG. 7B

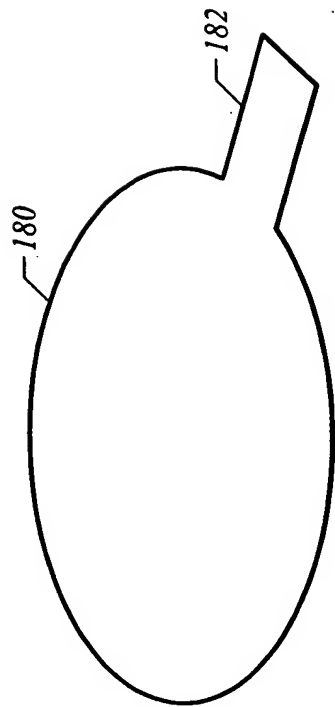


FIG. 7C

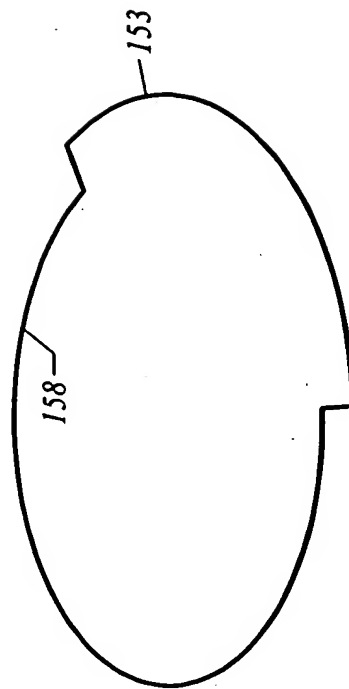


FIG. 7A

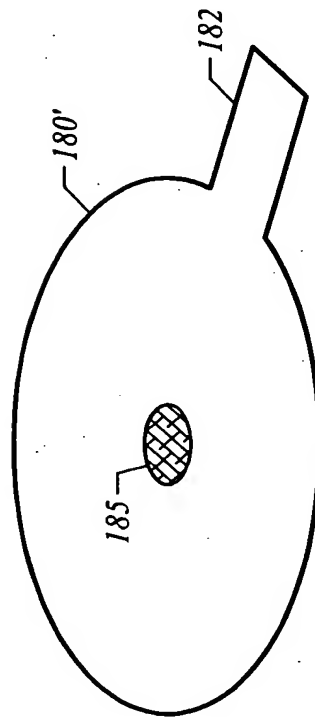


FIG. 7D

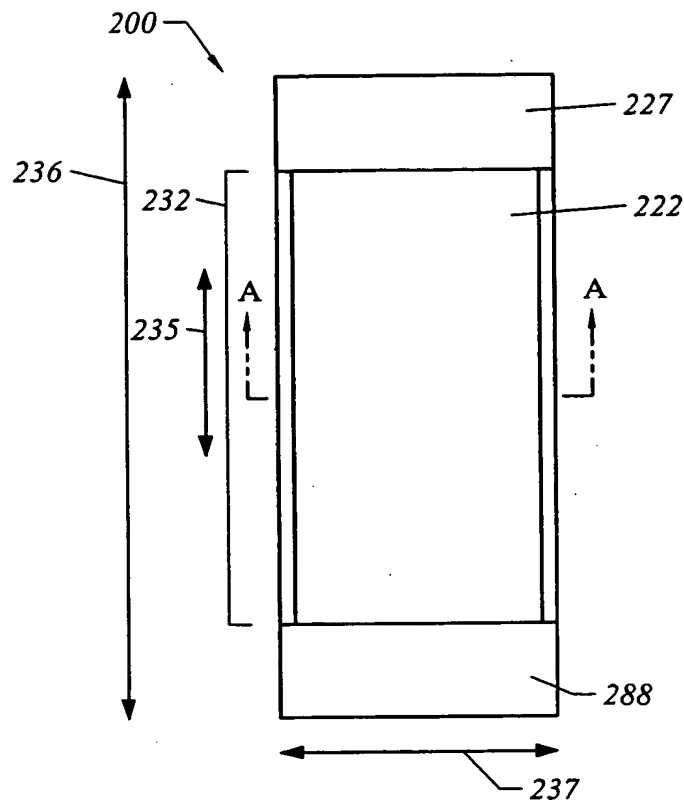


FIG. 8A

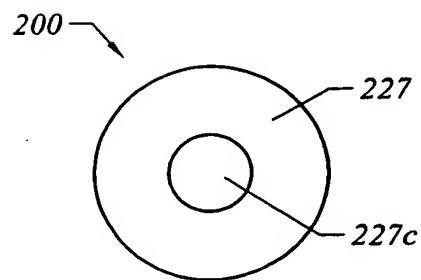
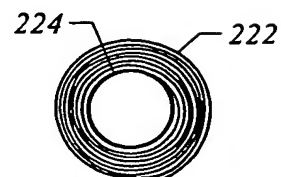


FIG. 8B



Section A-A

FIG. 8C

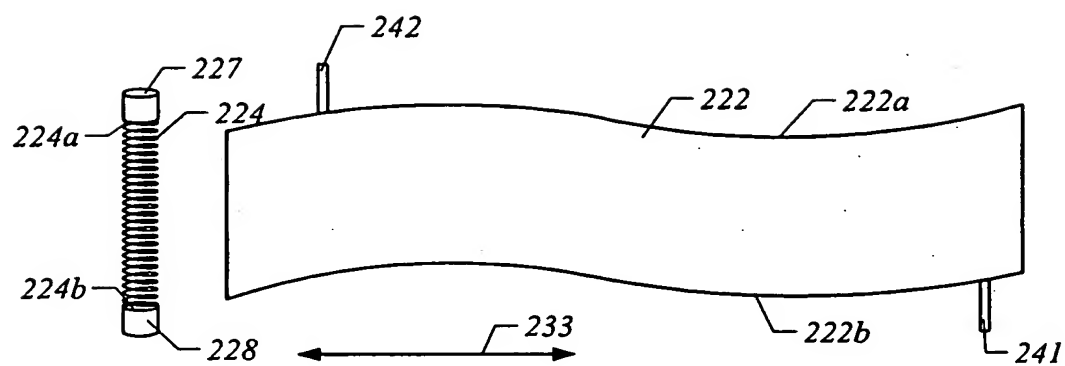


FIG. 8D

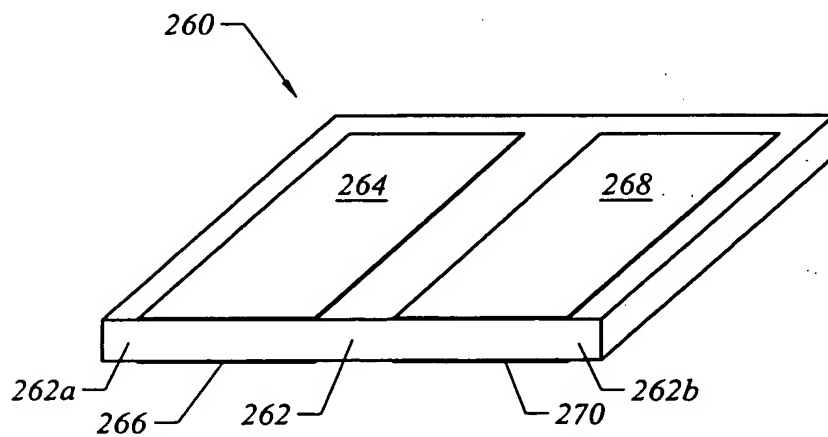


FIG. 8E

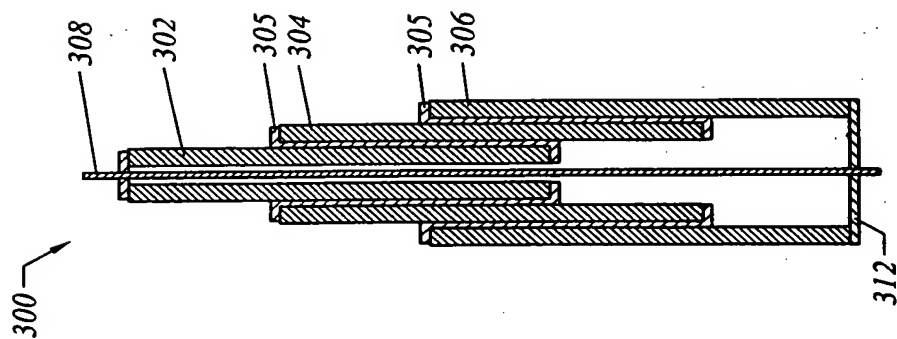


FIG. 9A

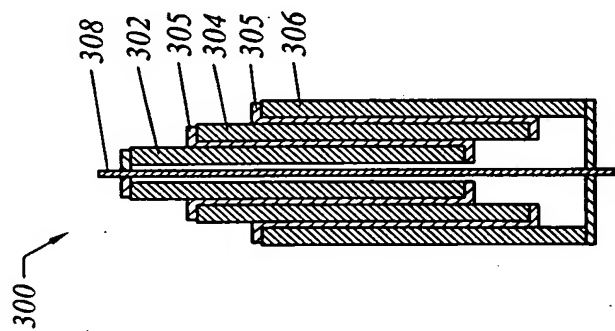


FIG. 9B

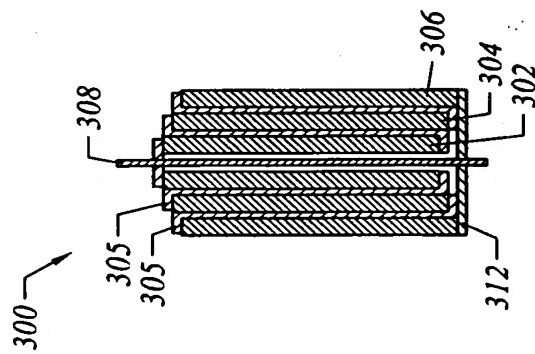


FIG. 9C

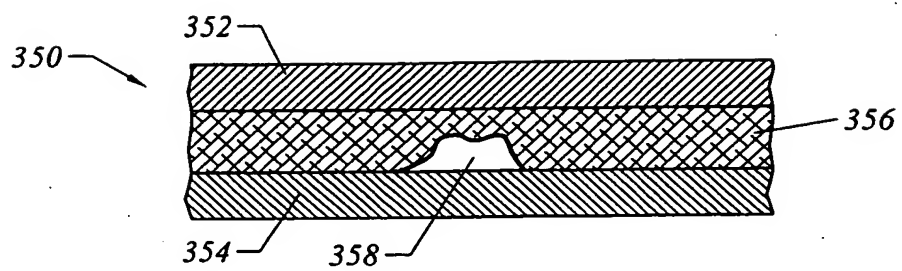


FIG. 10A
(Prior Art)

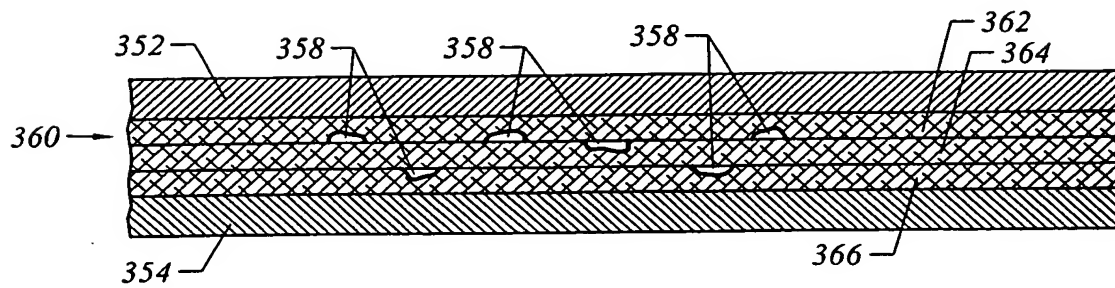


FIG. 10B

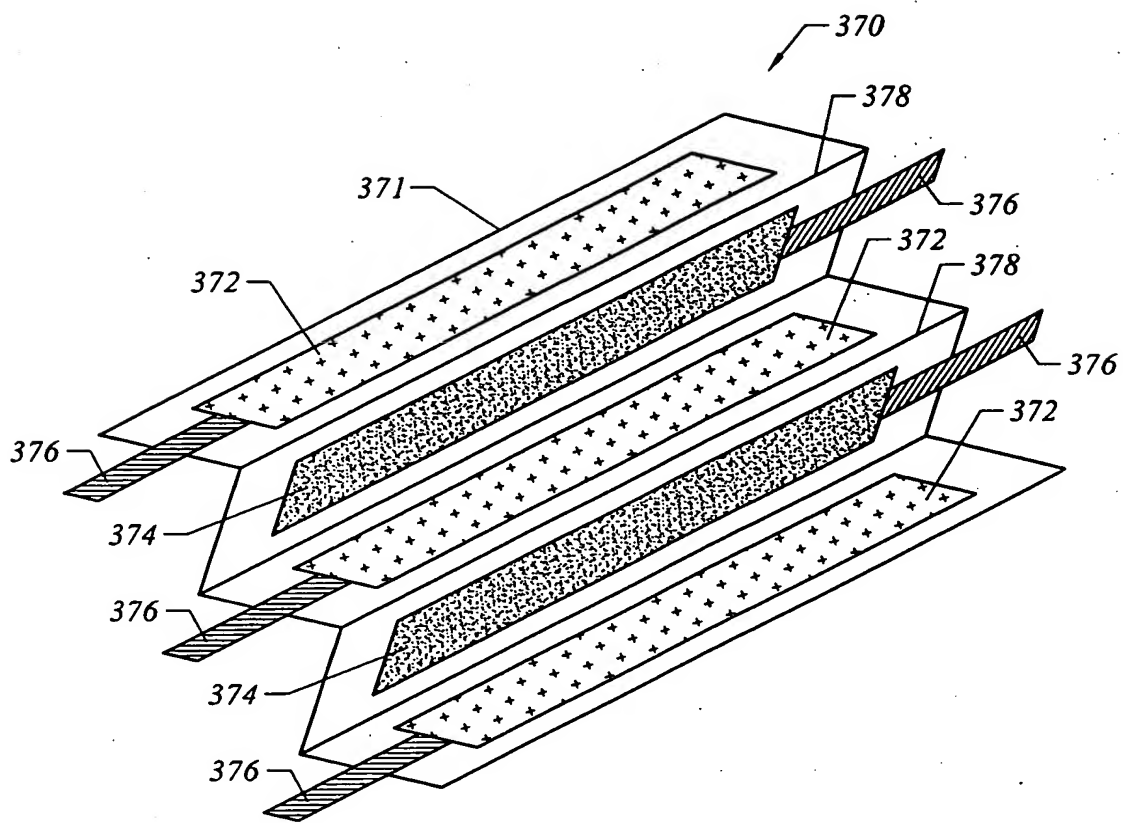


FIG. 11

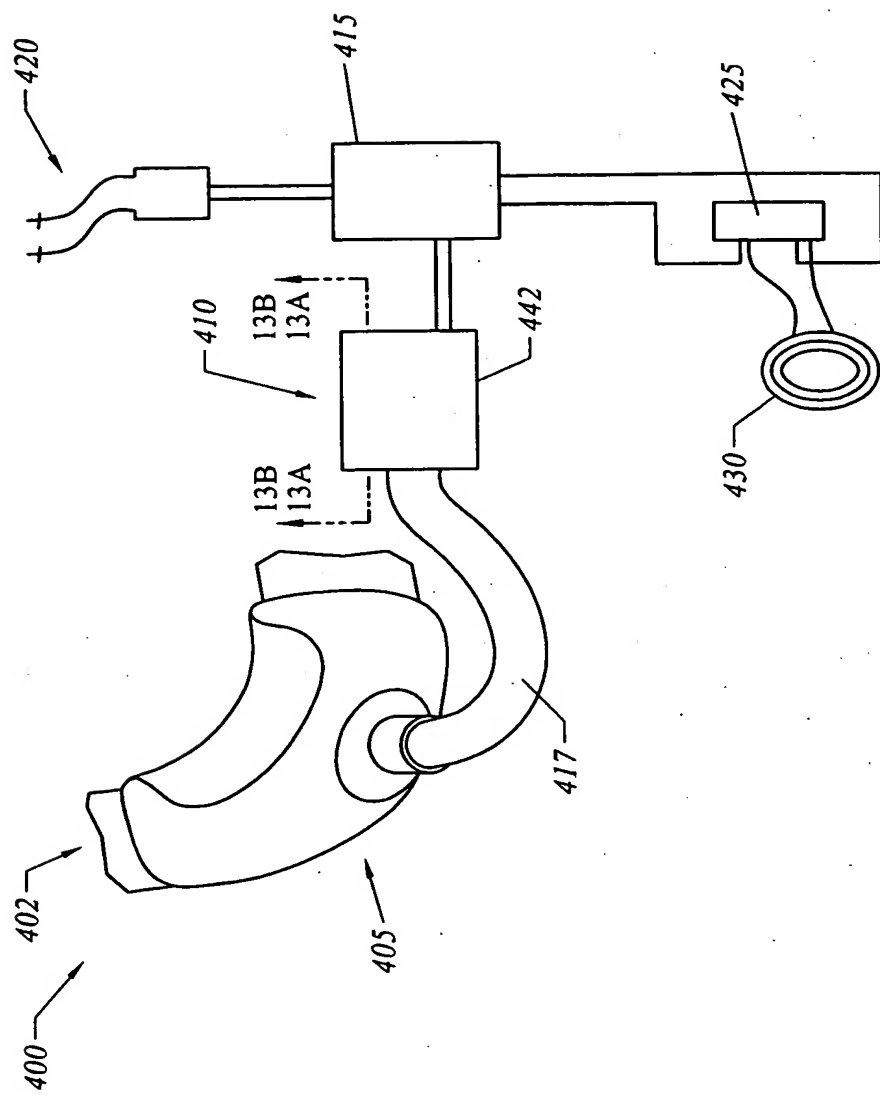


FIG. 12

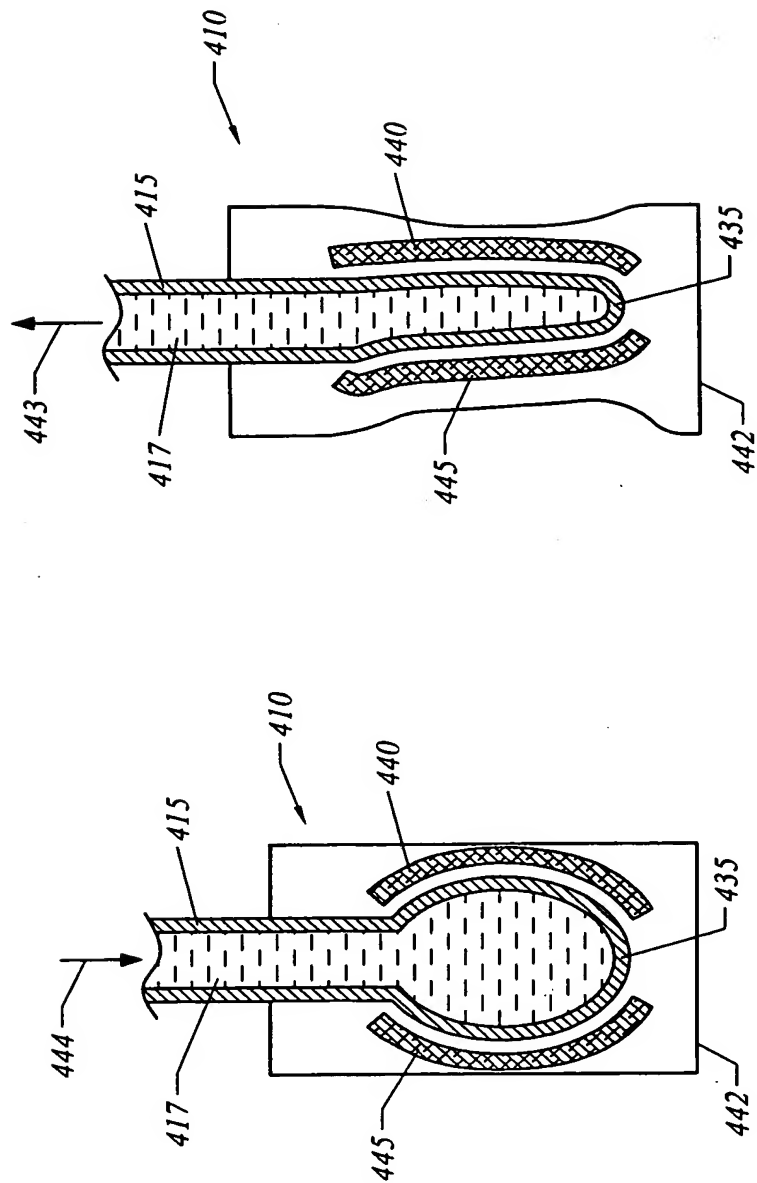


FIG. 13A

FIG. 13B

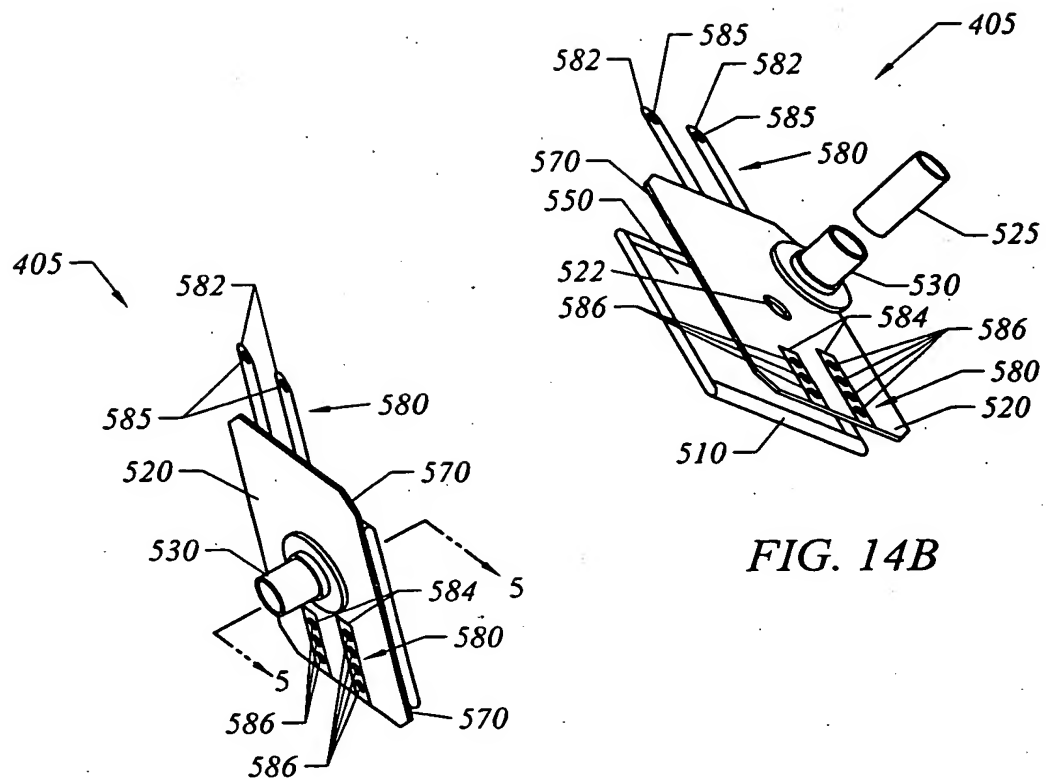


FIG. 14A

FIG. 14B

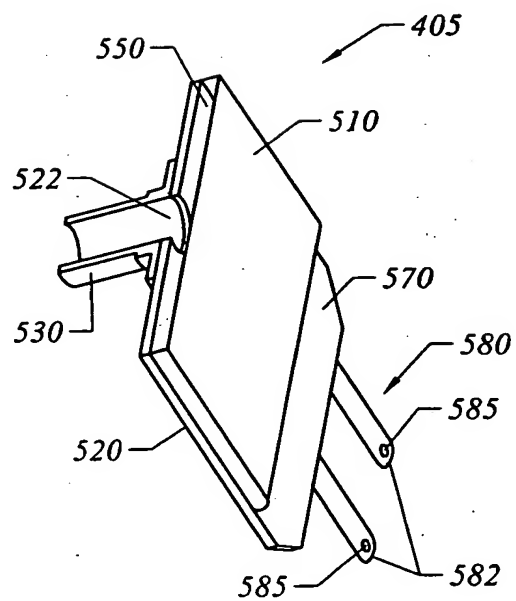


FIG. 14C

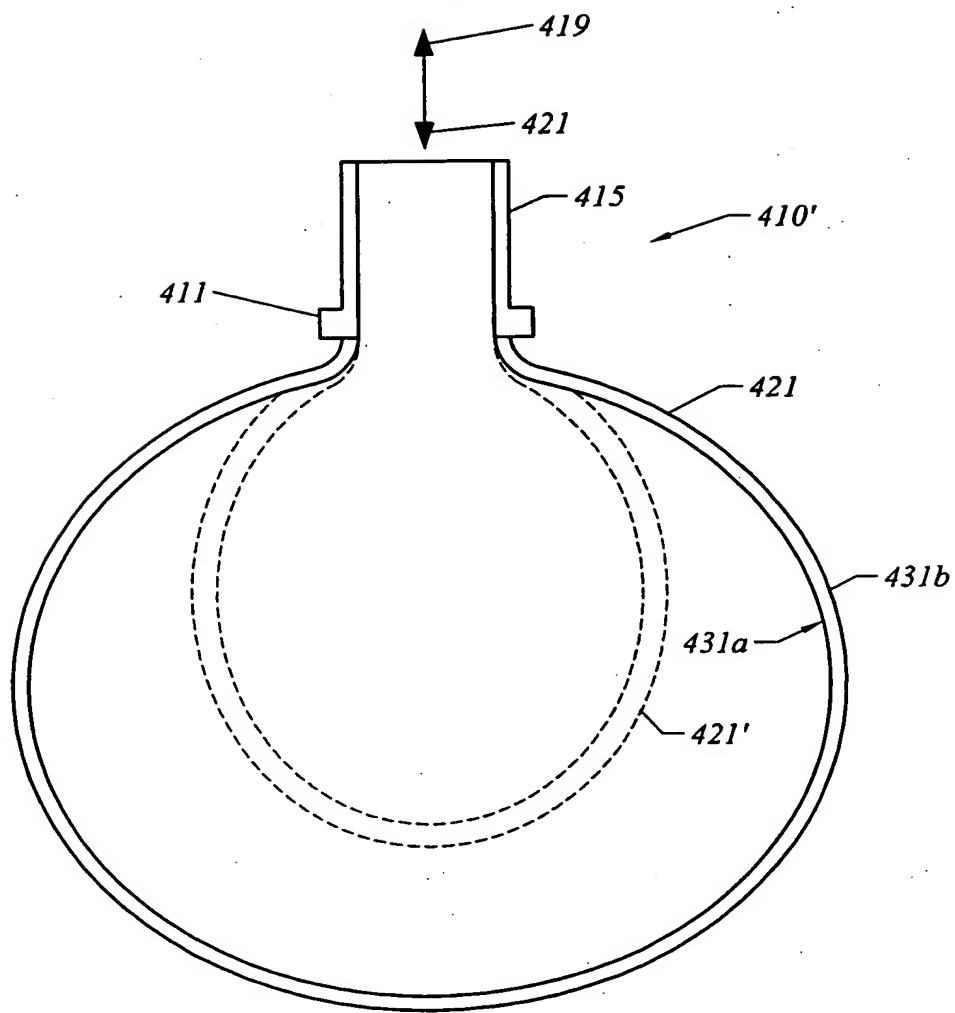


FIG. 15

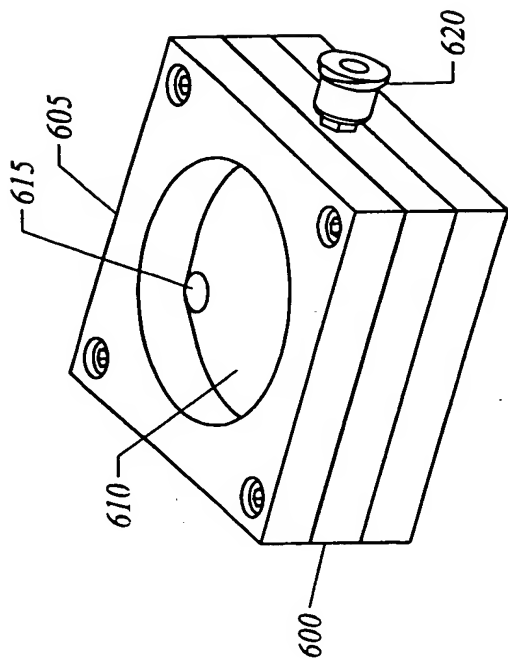


FIG. 16A

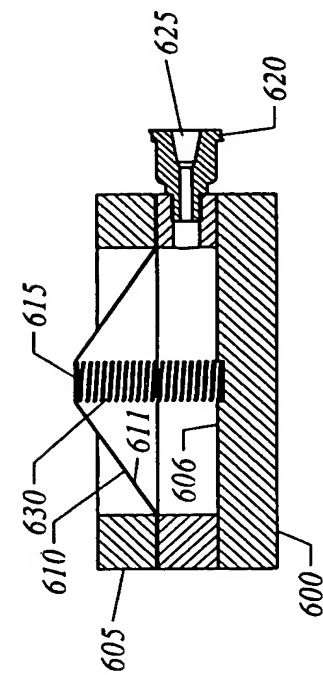


FIG. 16C

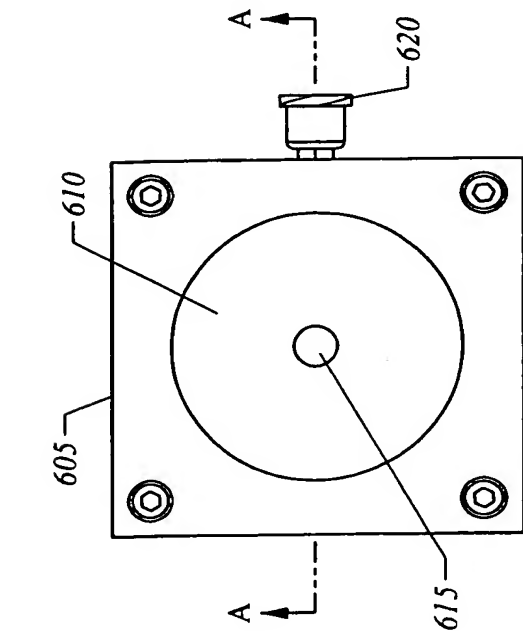


FIG. 16B

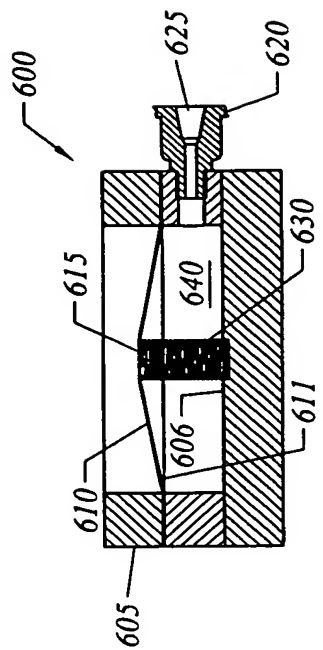
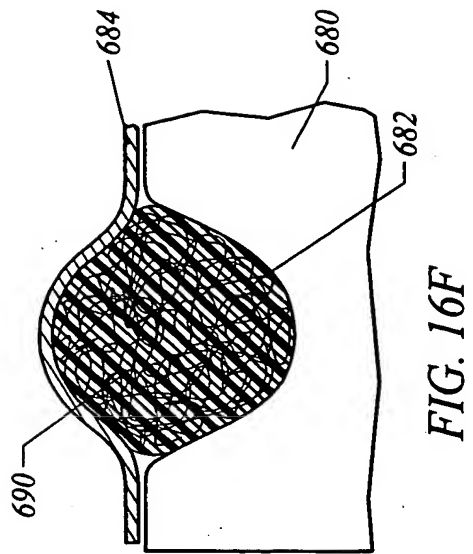
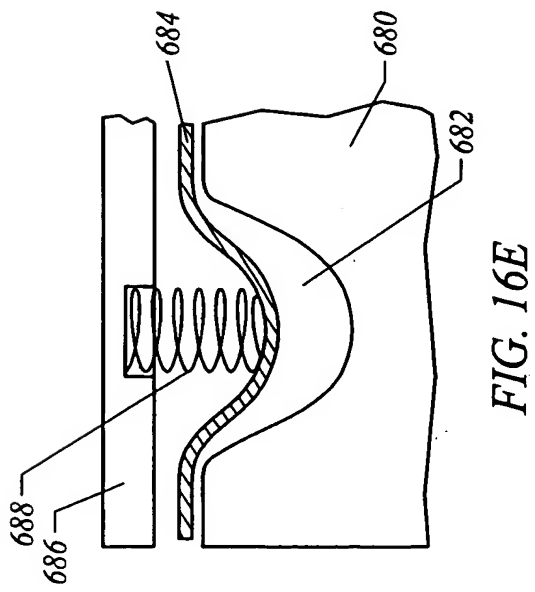


FIG. 16D



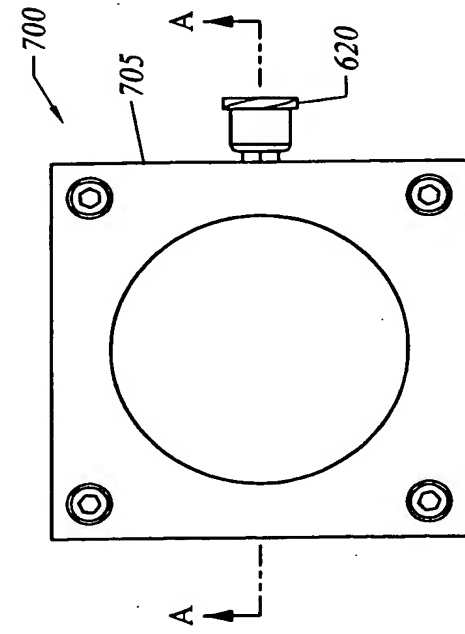


FIG. 17A

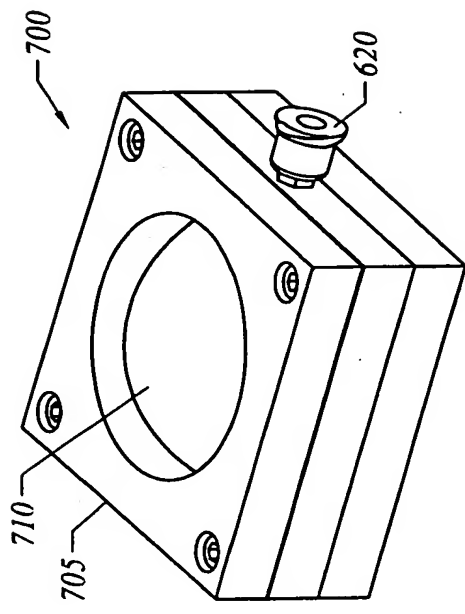


FIG. 17B

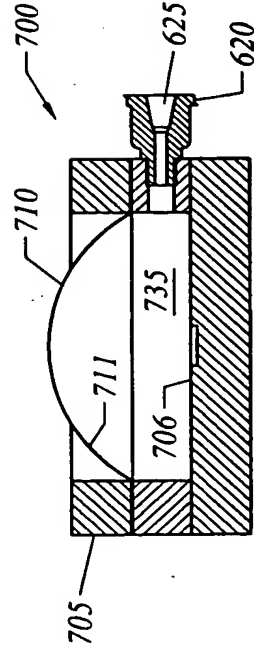


FIG. 17C

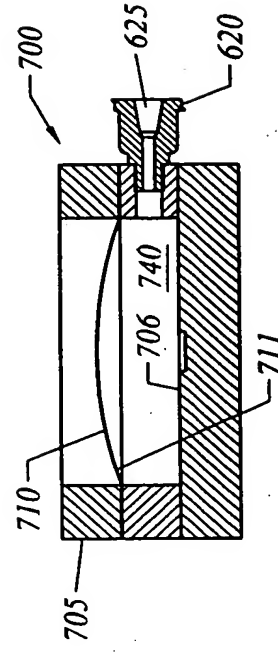


FIG. 17D

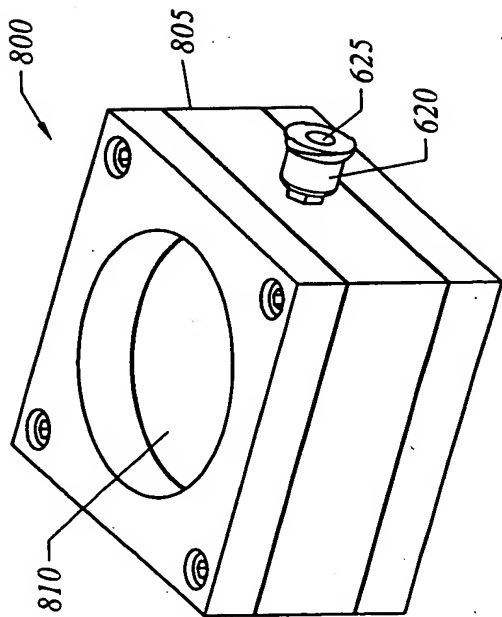


FIG. 18B

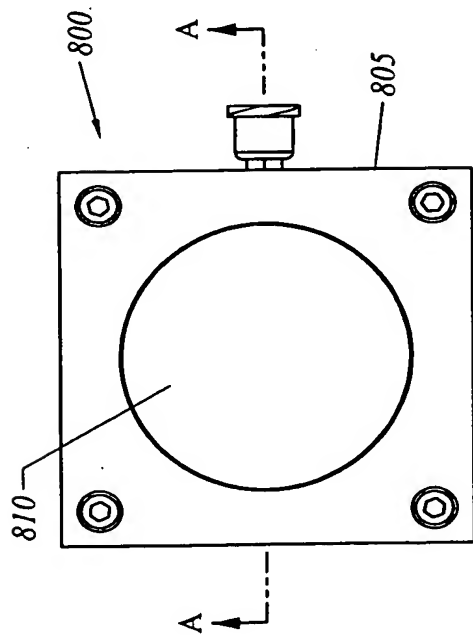


FIG. 18A

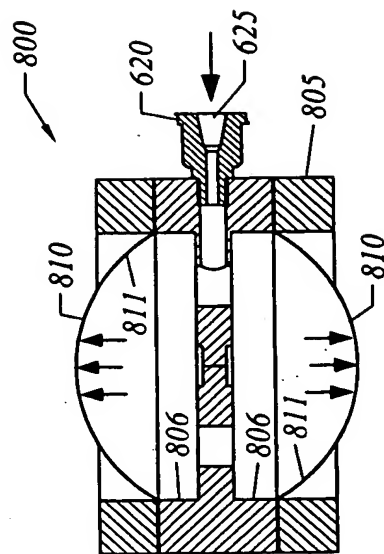


FIG. 18D

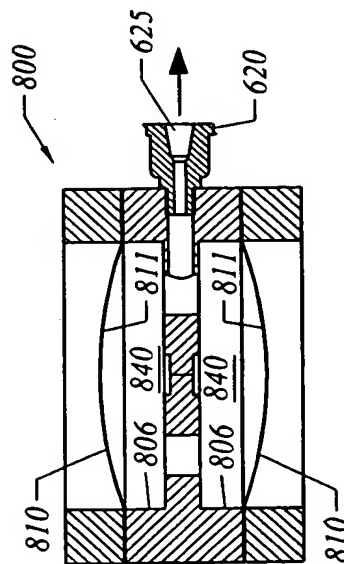


FIG. 18C

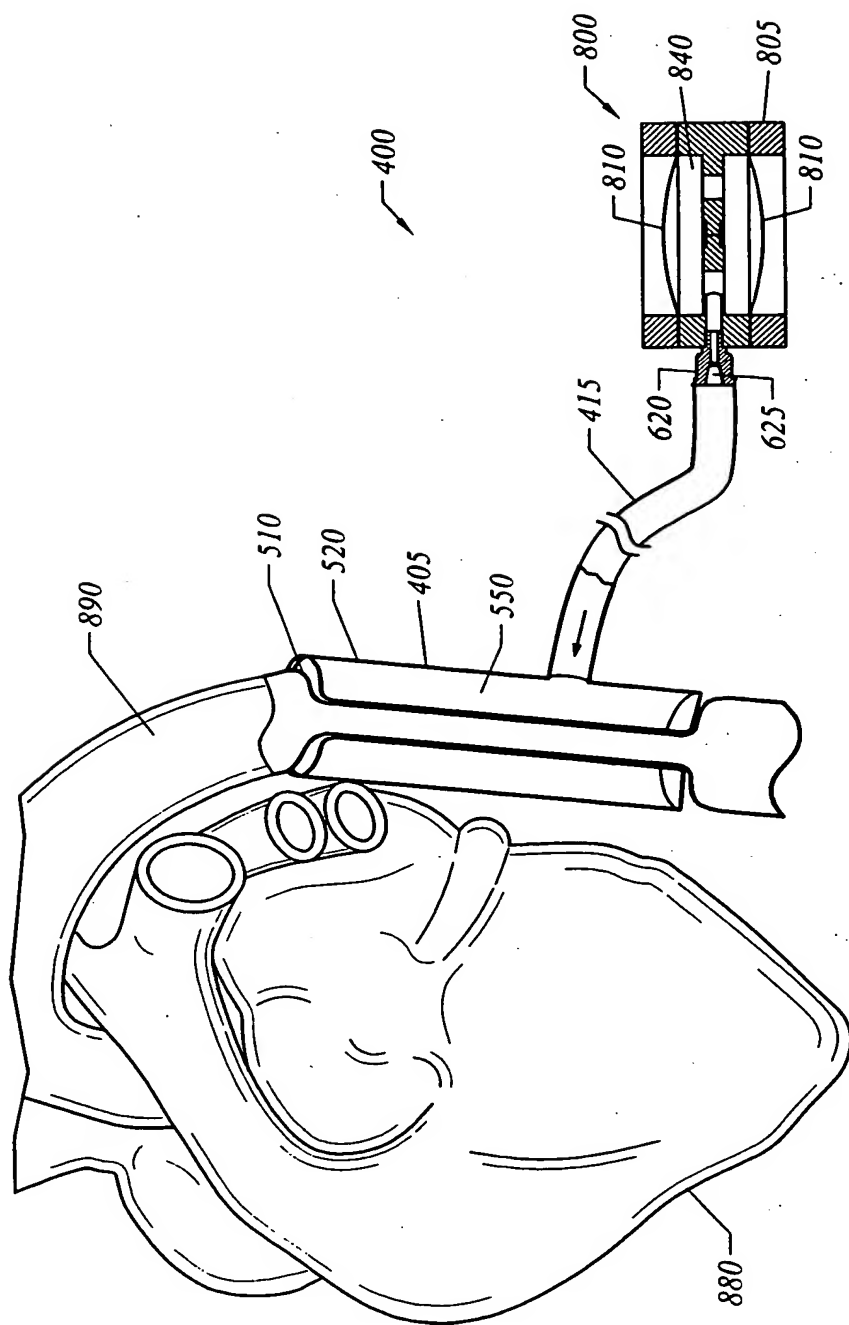


FIG. 19A

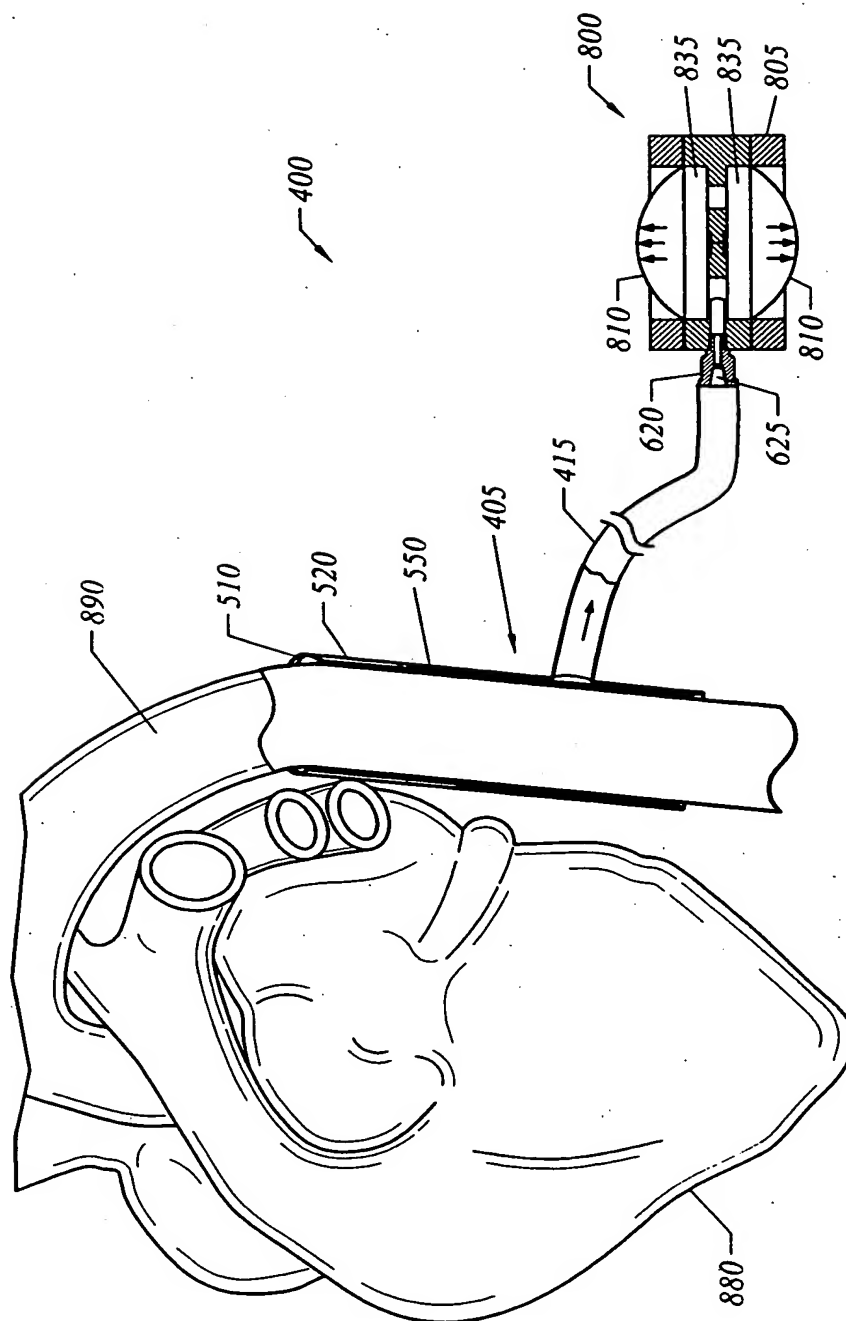


FIG. 19B.

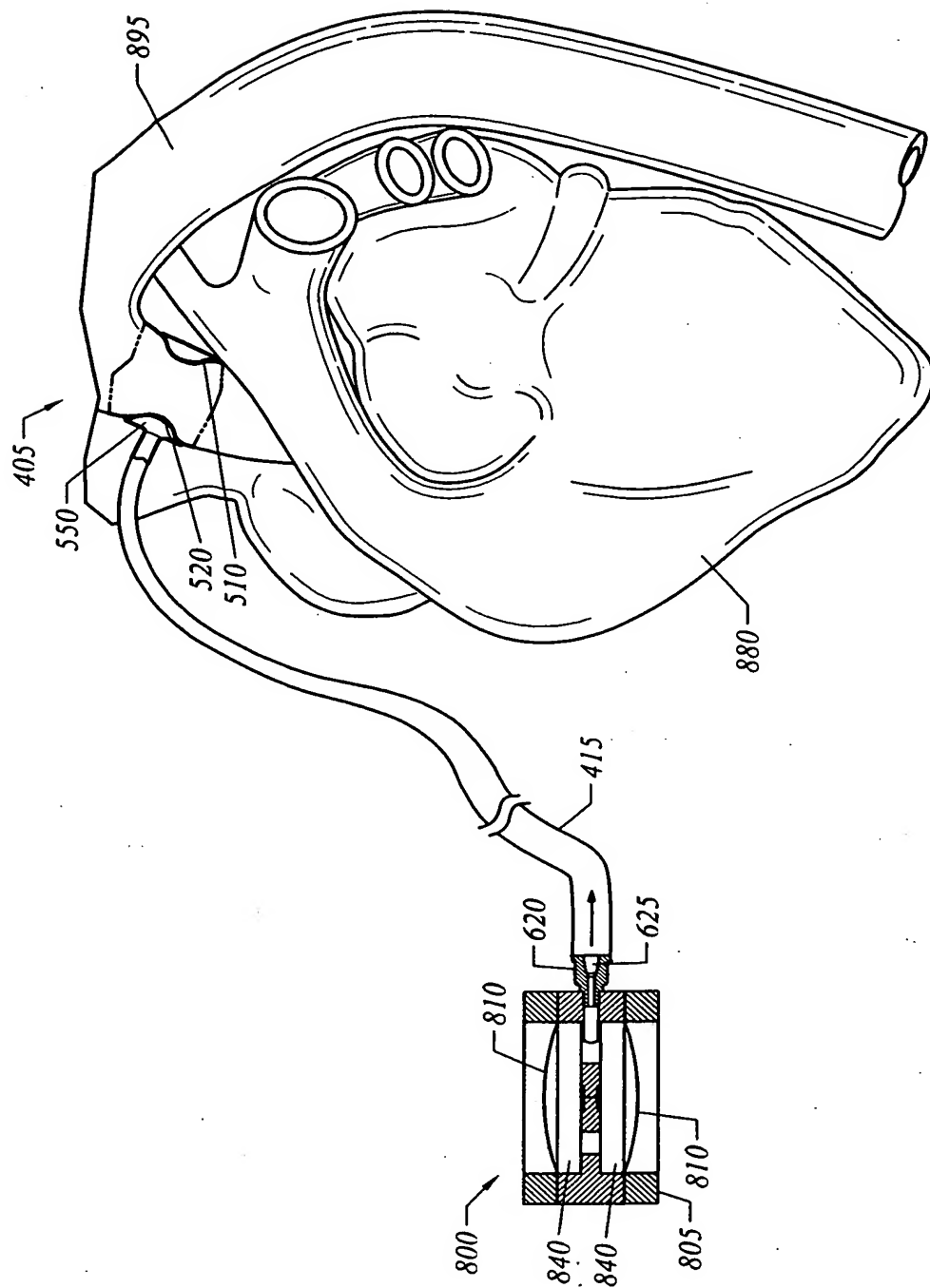


FIG. 19C

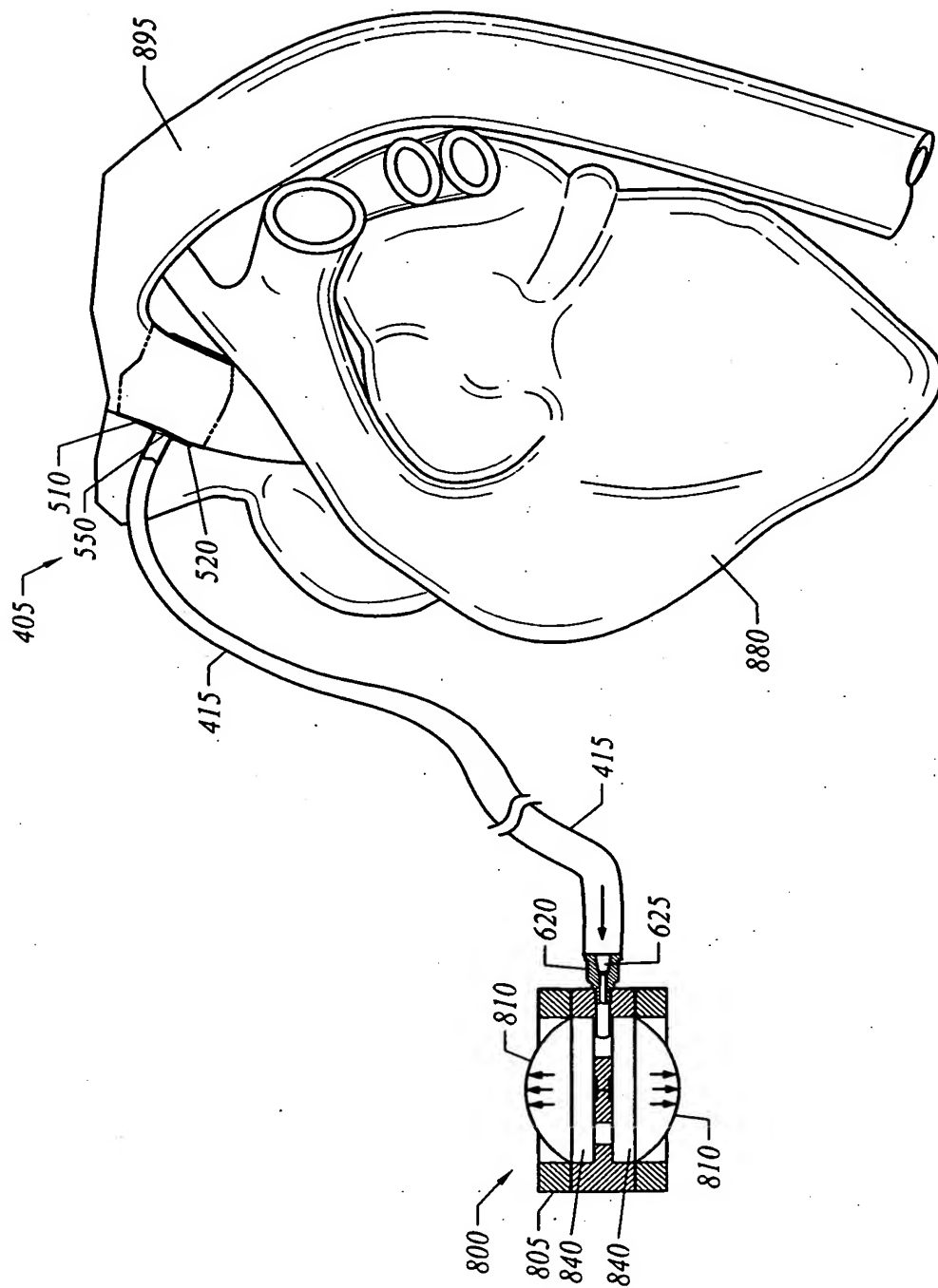


FIG. 19D

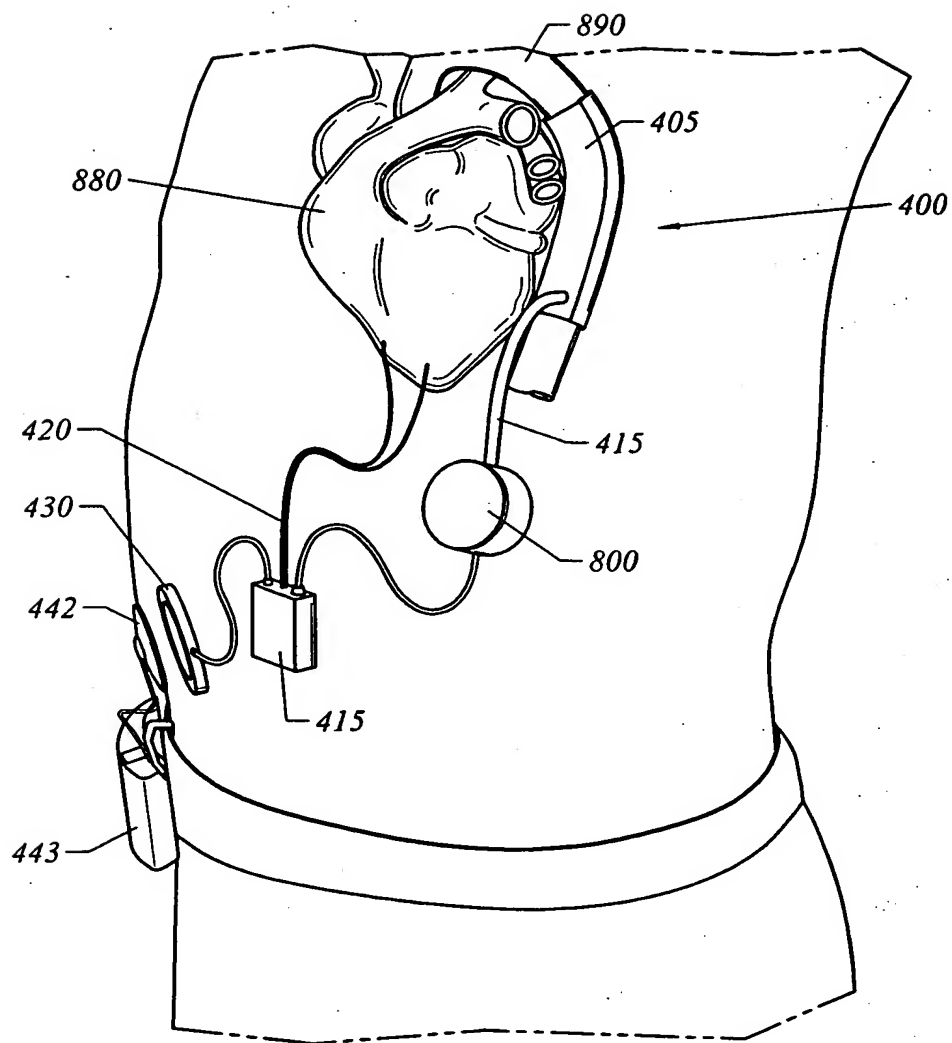


FIG. 20

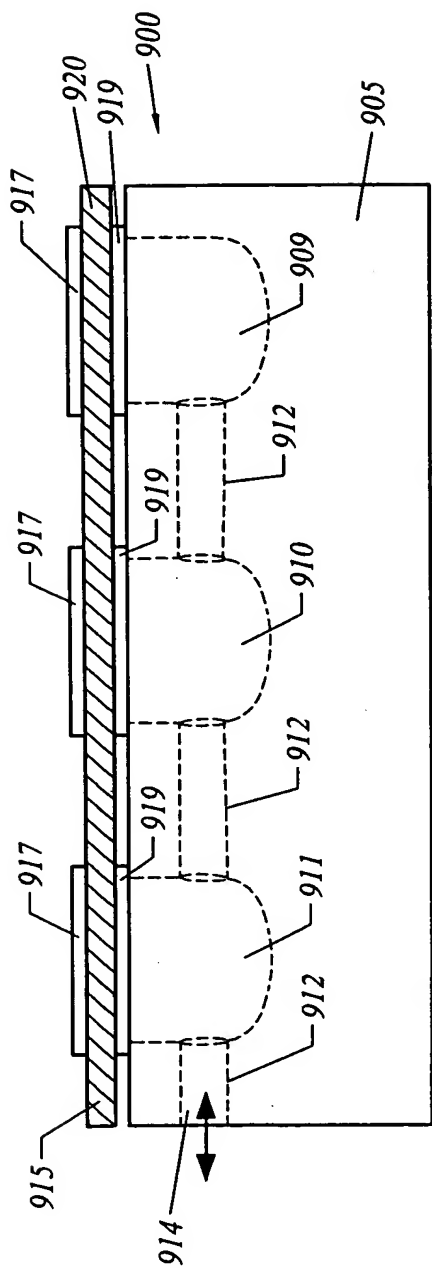


FIG. 21

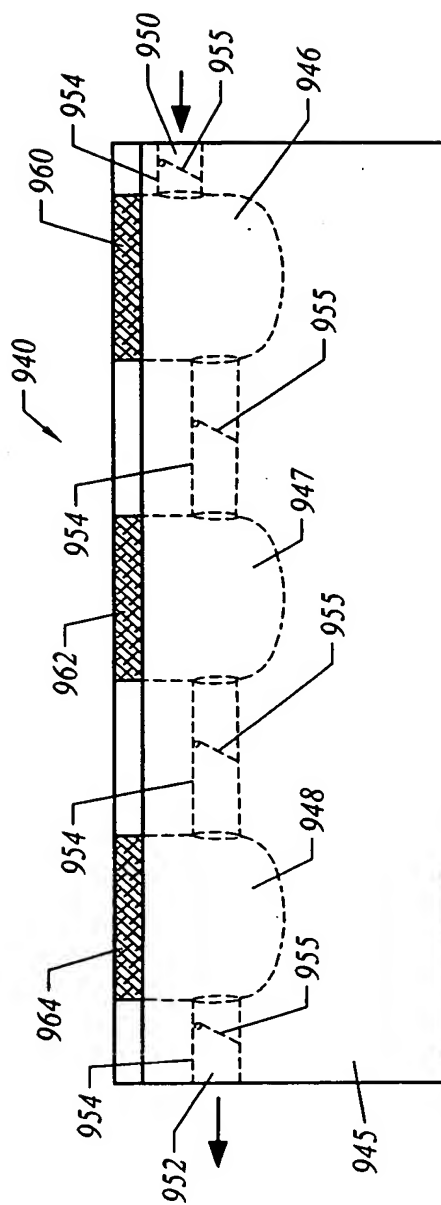


FIG. 22

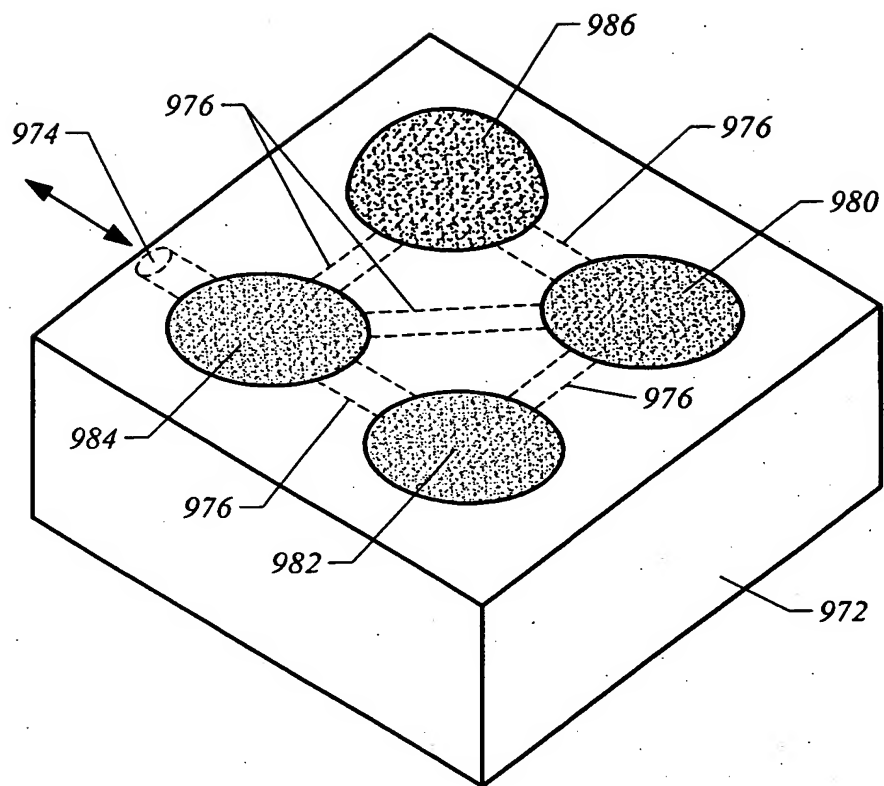


FIG. 23

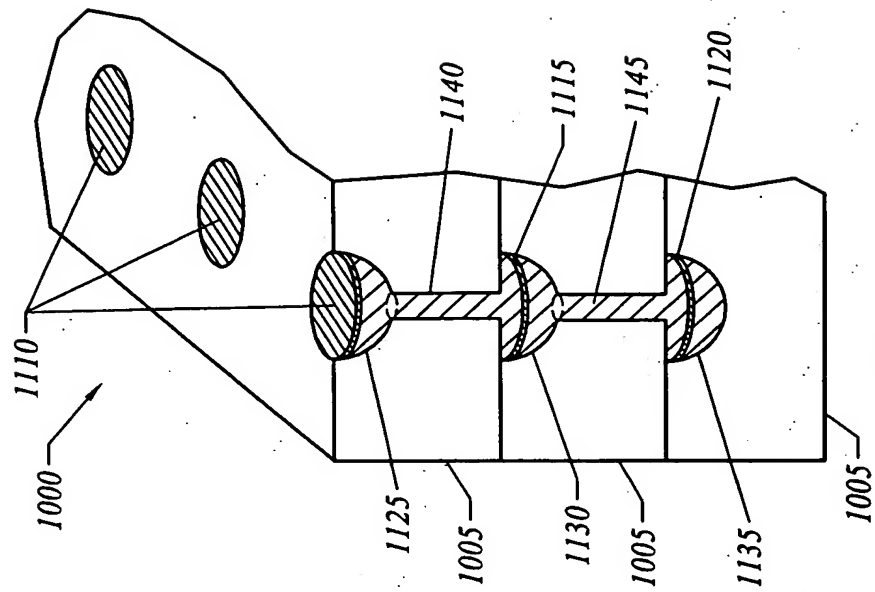


FIG. 24A

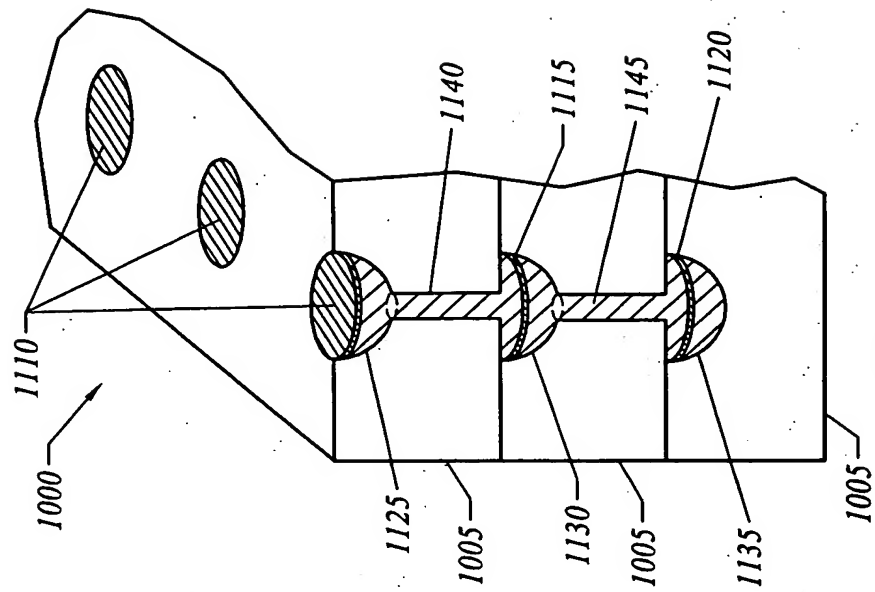


FIG. 24B

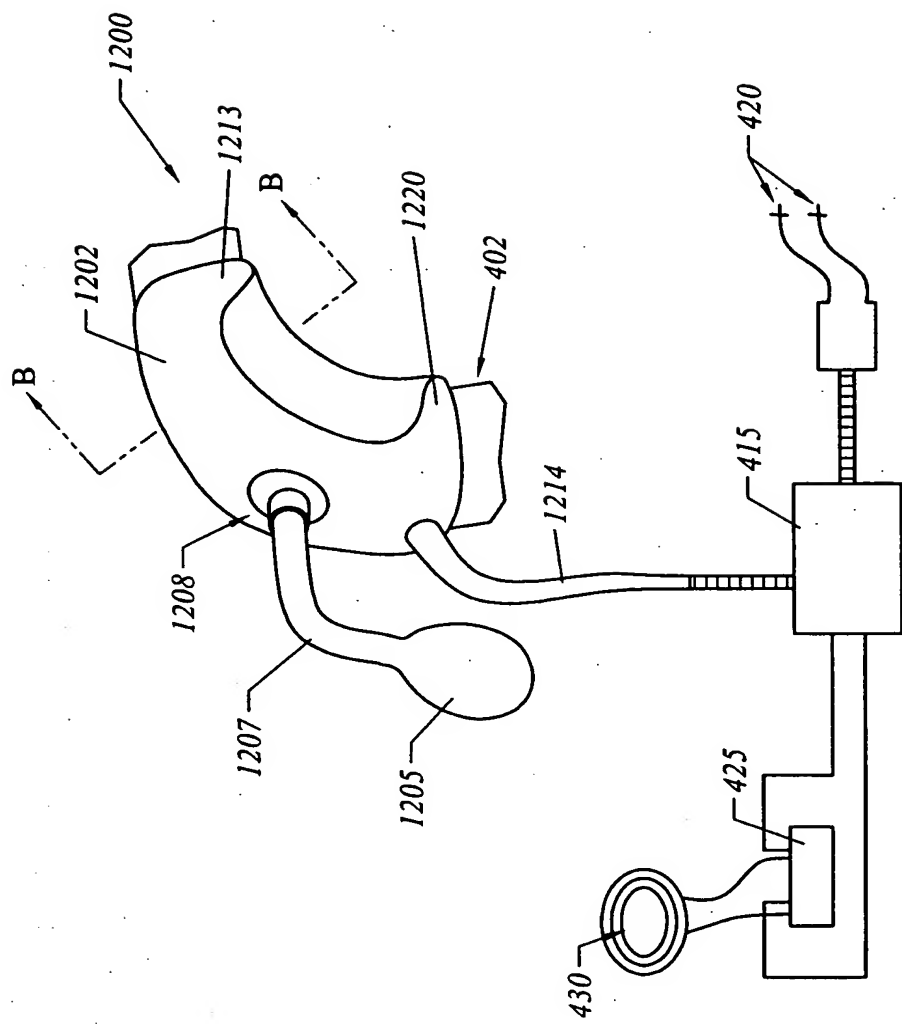


FIG. 25

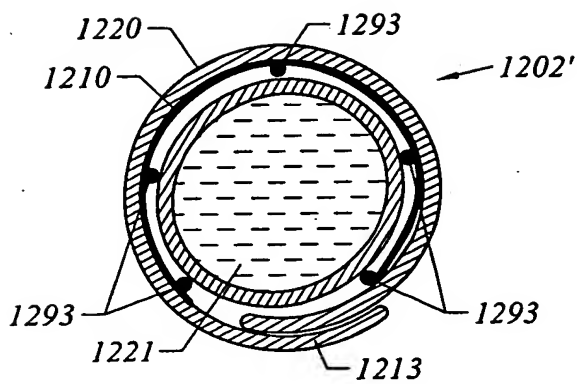


FIG. 26A

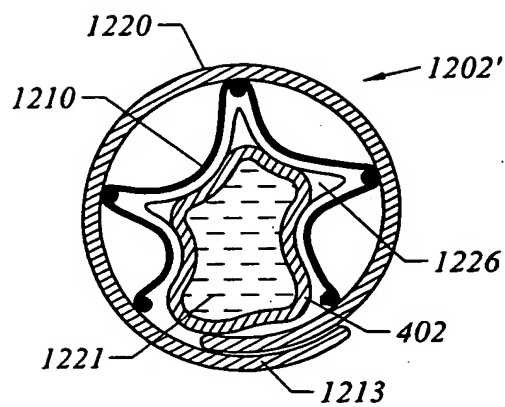


FIG. 26B

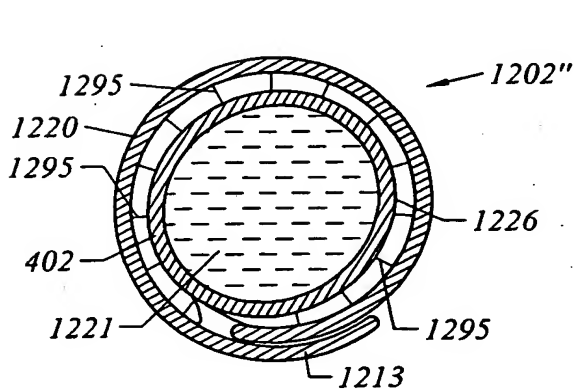


FIG. 27A

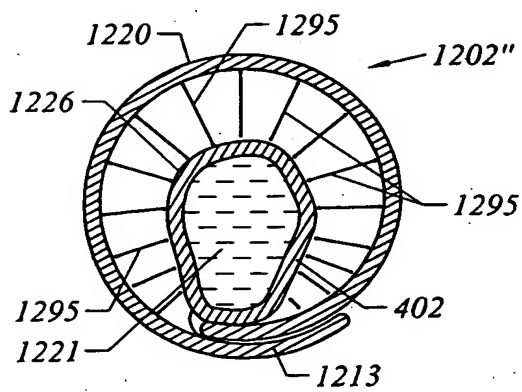


FIG. 27B

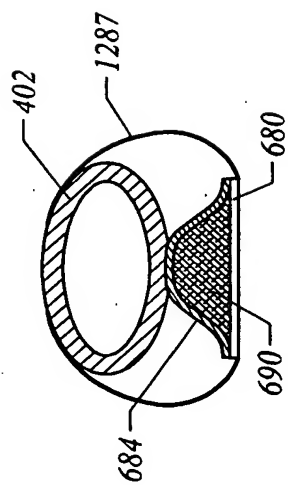


FIG. 28A

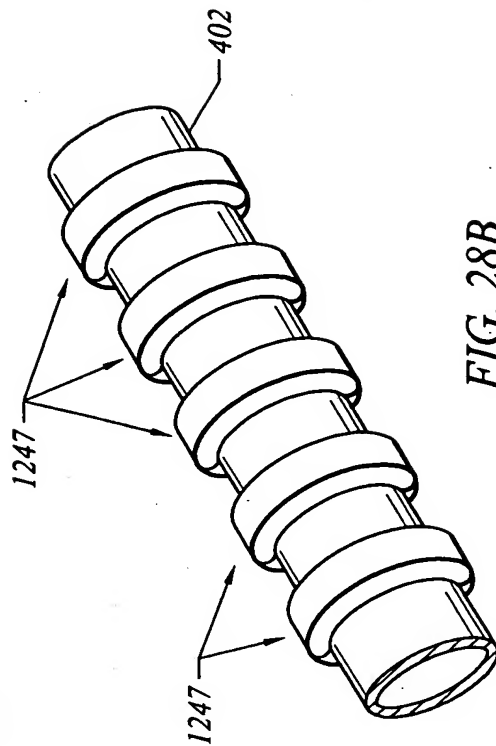


FIG. 28B

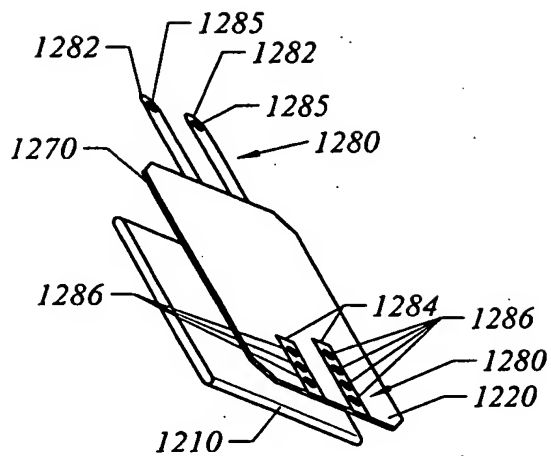


FIG. 29

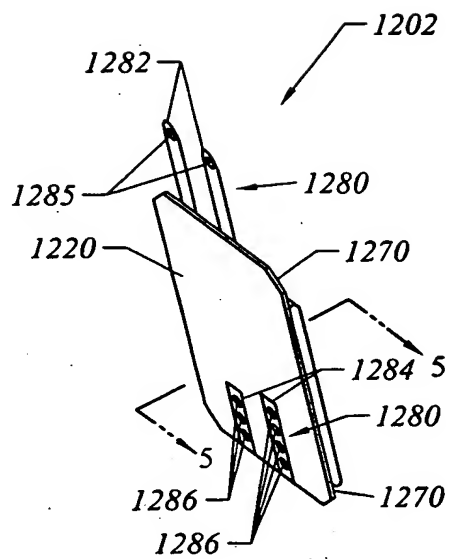


FIG. 30

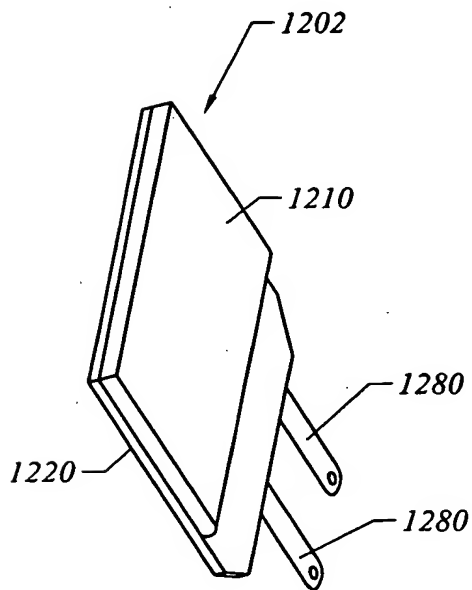


FIG. 31

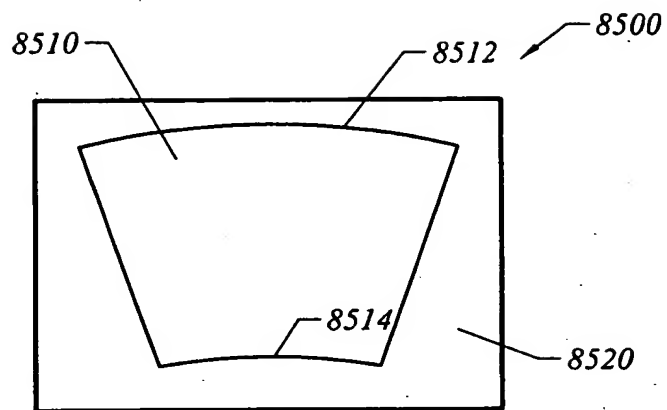


FIG. 32A

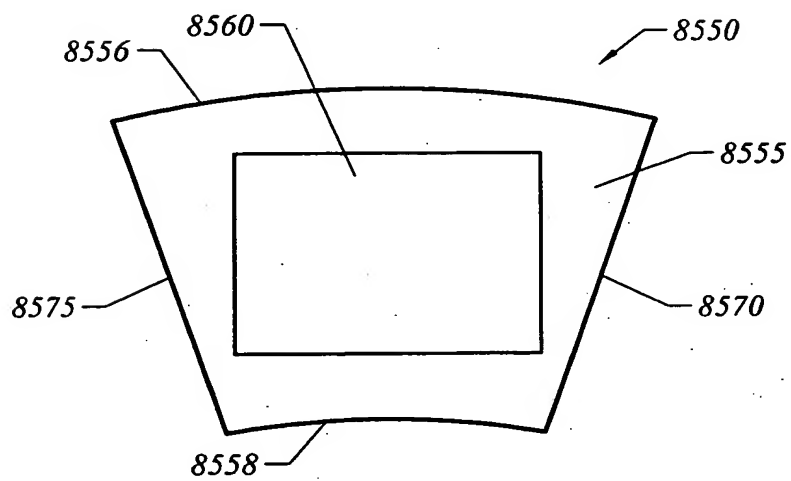


FIG. 32B

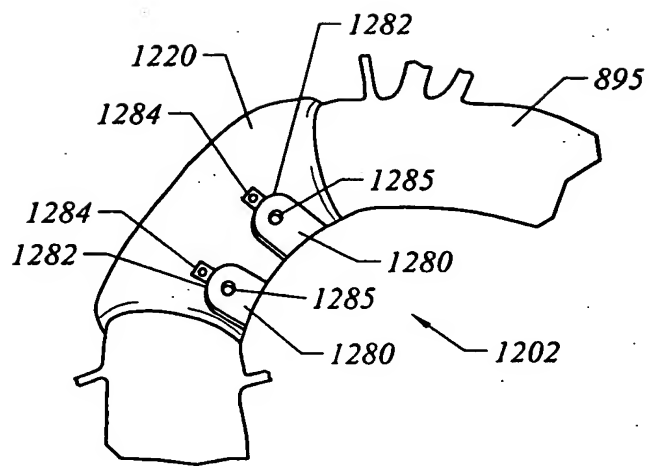


FIG. 33

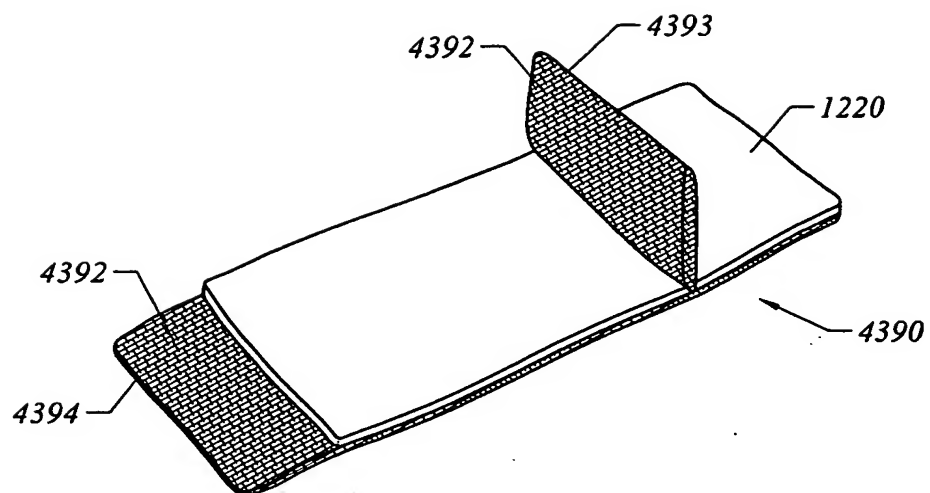


FIG. 34A

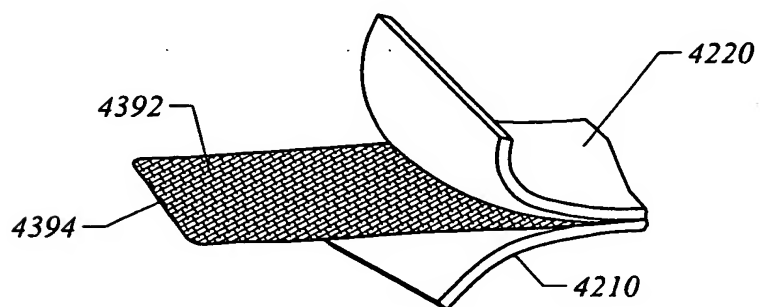


FIG. 34B

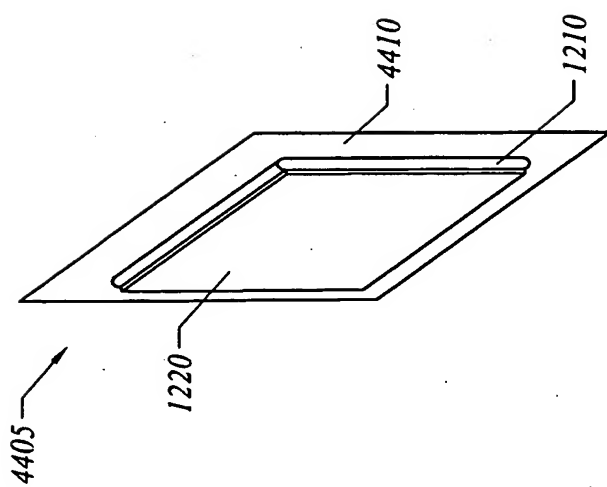


FIG. 35

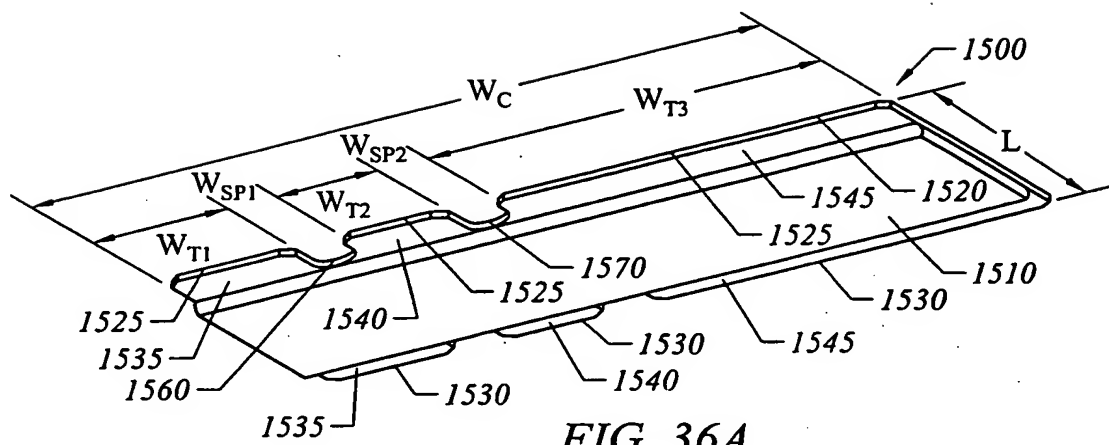


FIG. 36A

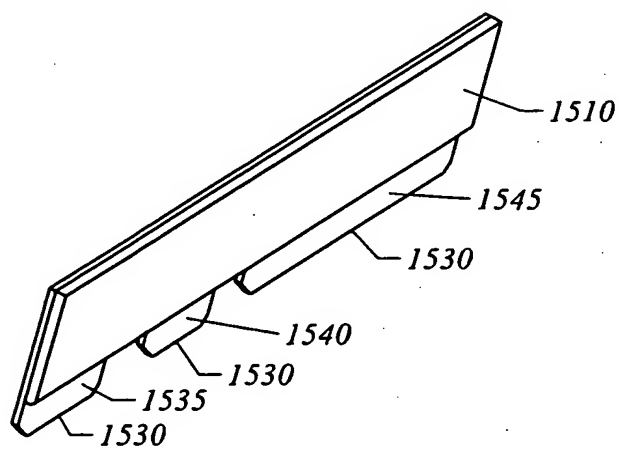


FIG. 36B

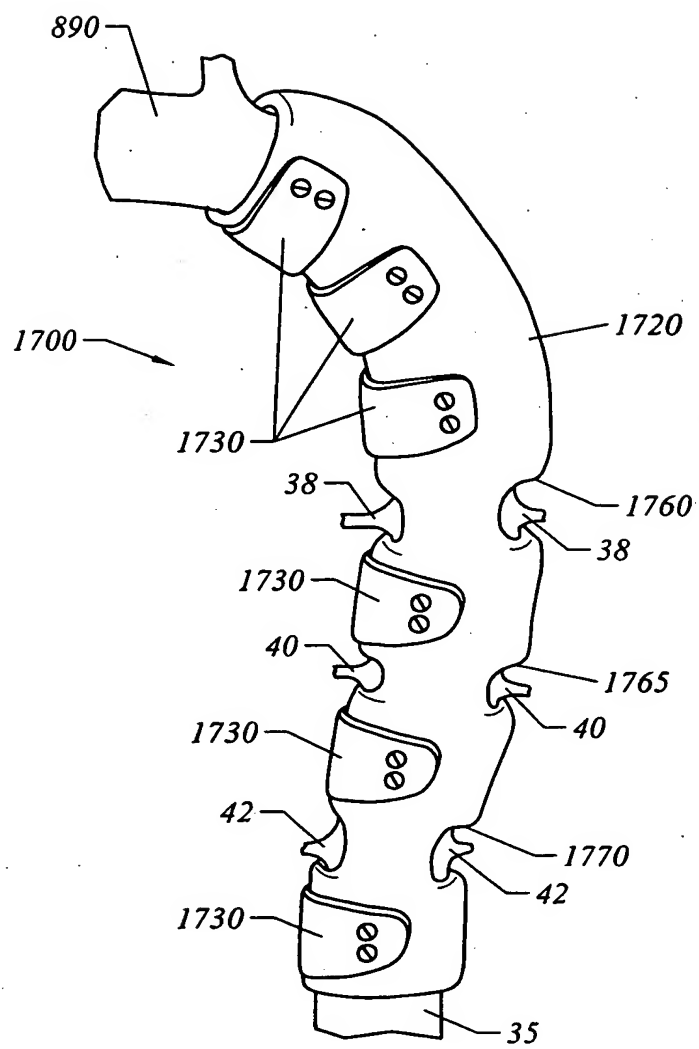


FIG. 37A

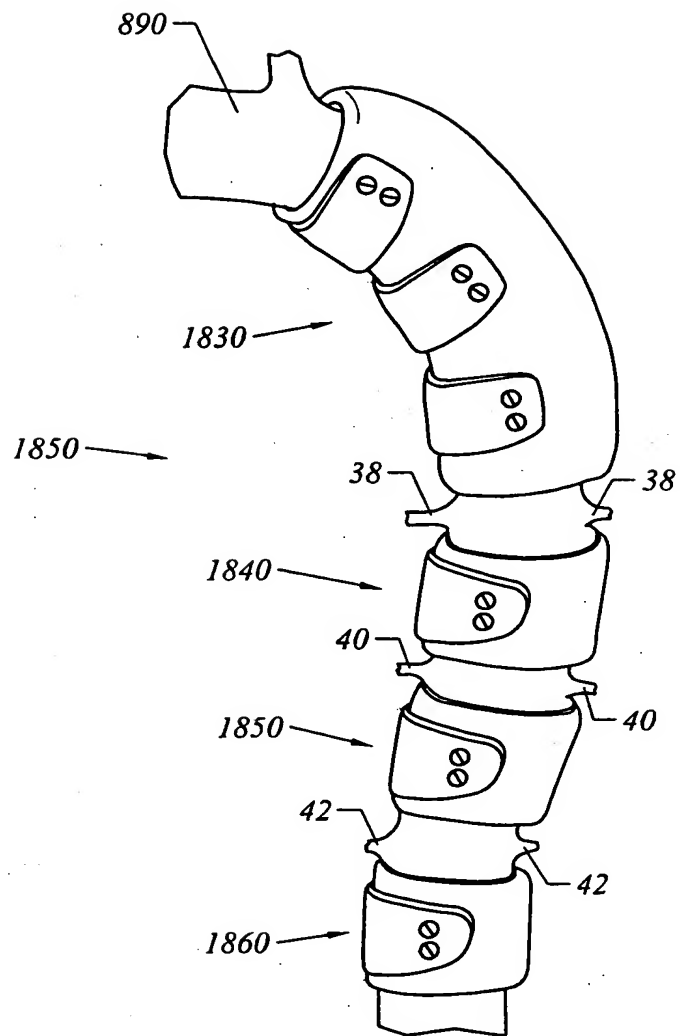


FIG. 37B

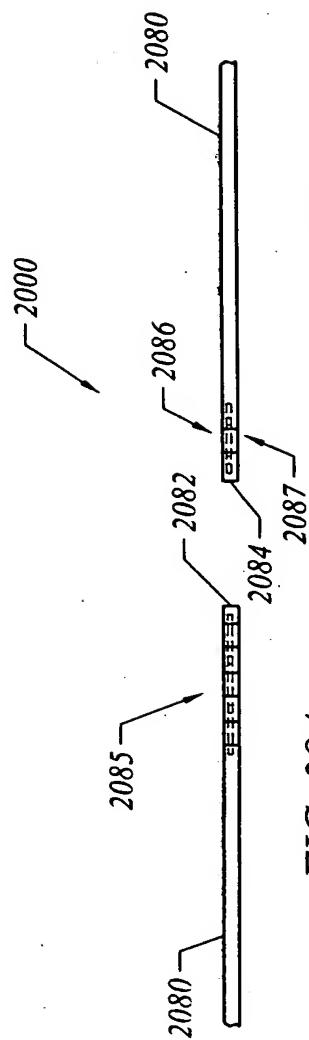


FIG. 38C

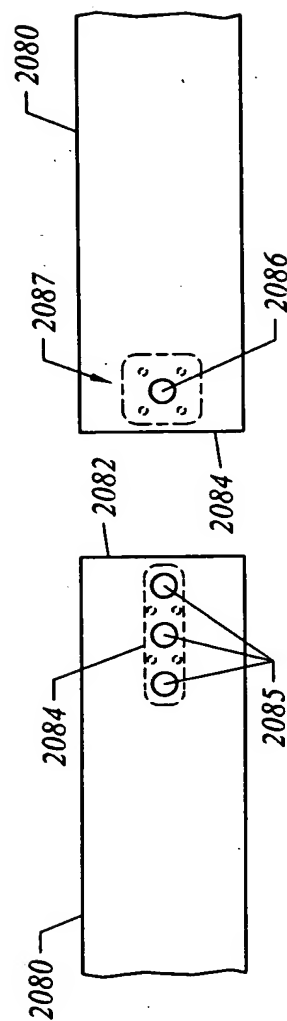


FIG. 38D

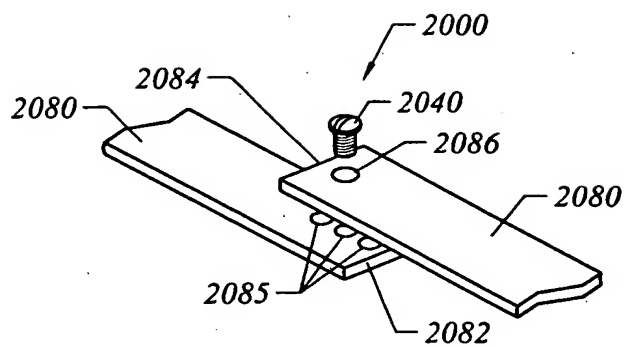


FIG. 39A

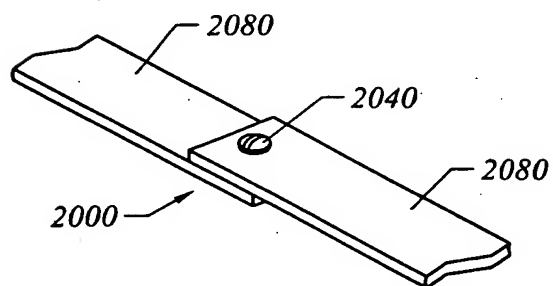


FIG. 39B

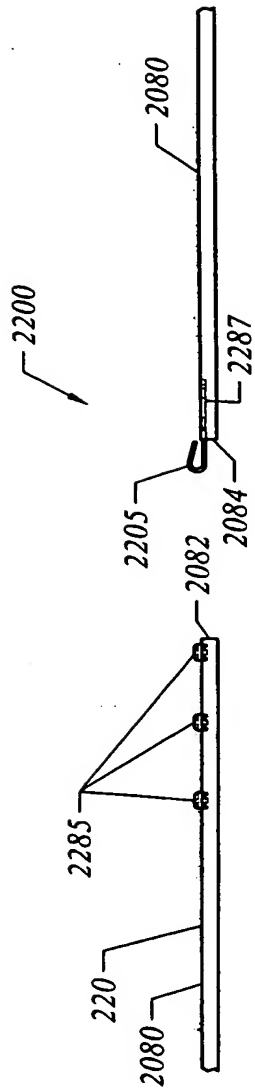


FIG. 40C

FIG. 40A

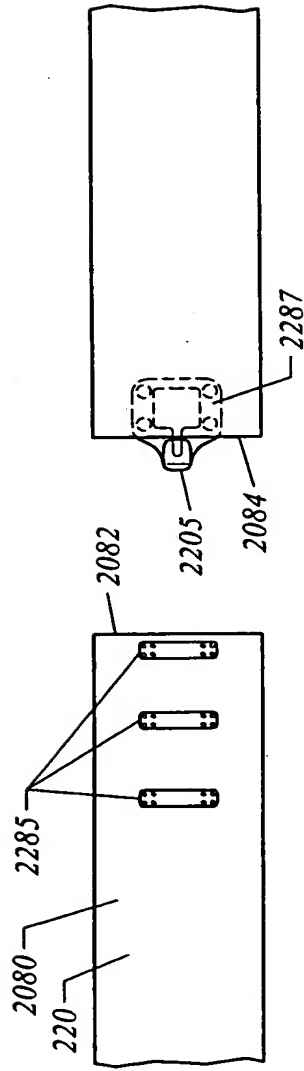


FIG. 40D

FIG. 40B

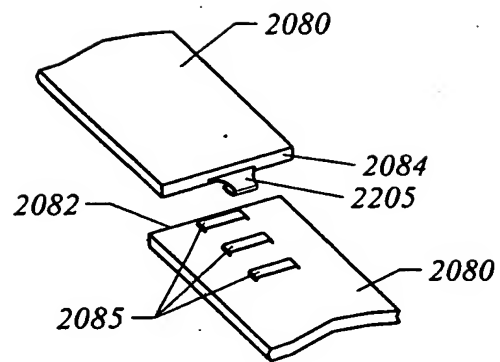


FIG. 41A

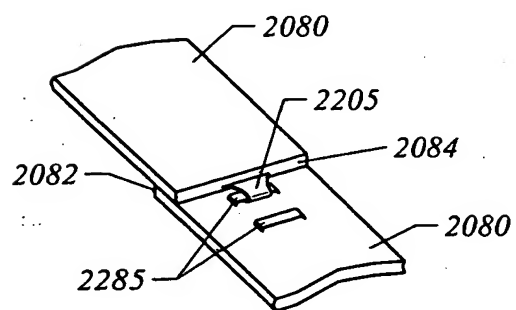


FIG. 41B

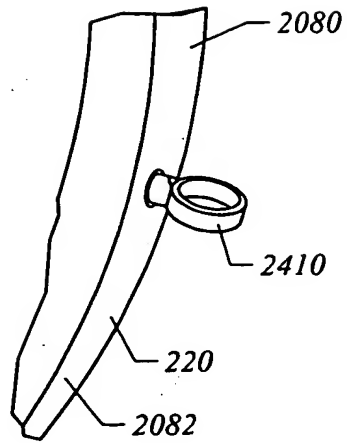


FIG. 42

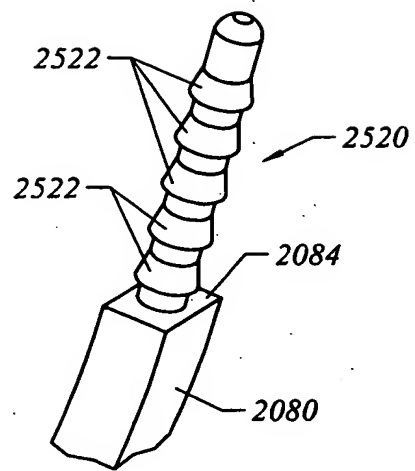


FIG. 43

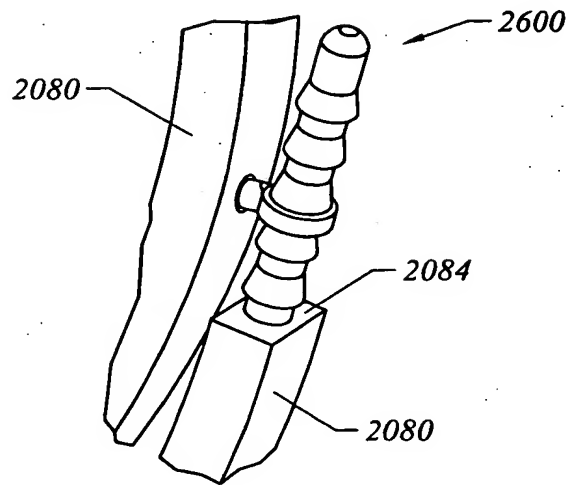


FIG. 44

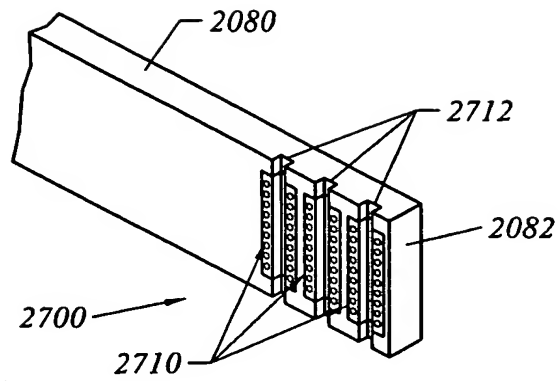


FIG. 45A

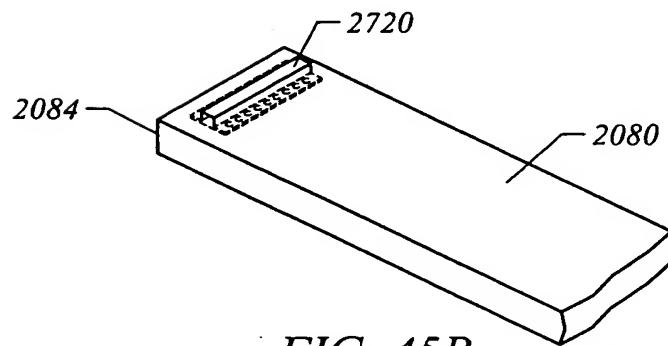


FIG. 45B

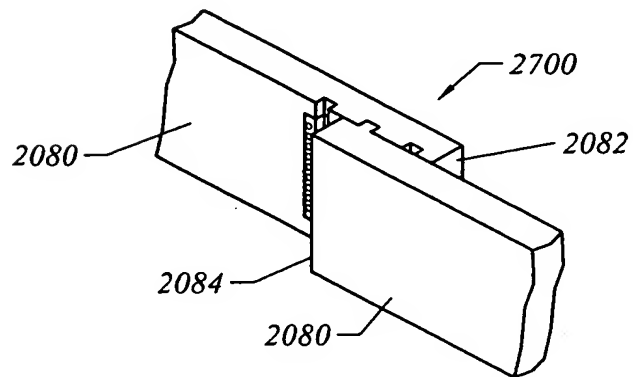


FIG. 46

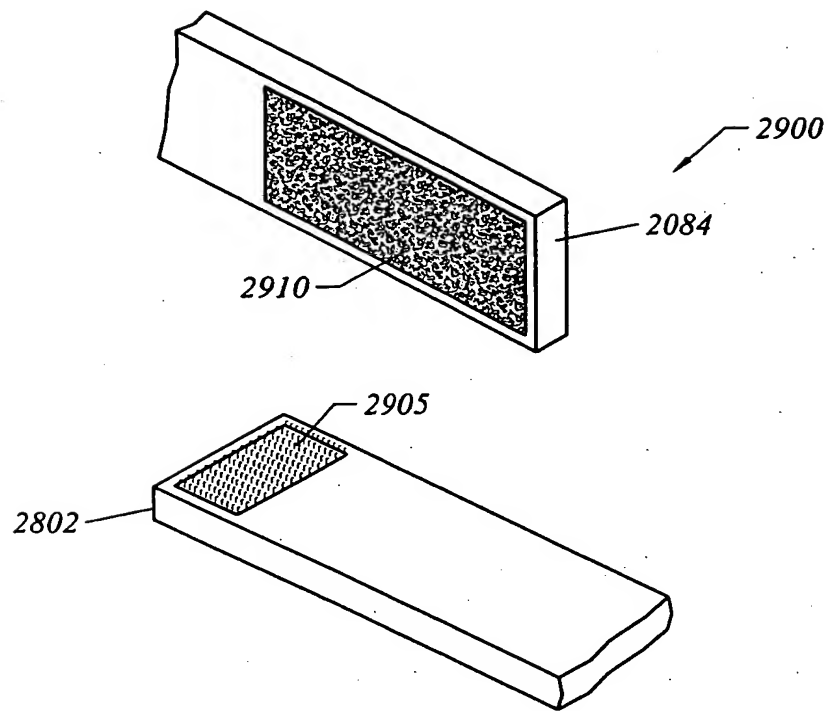


FIG. 47

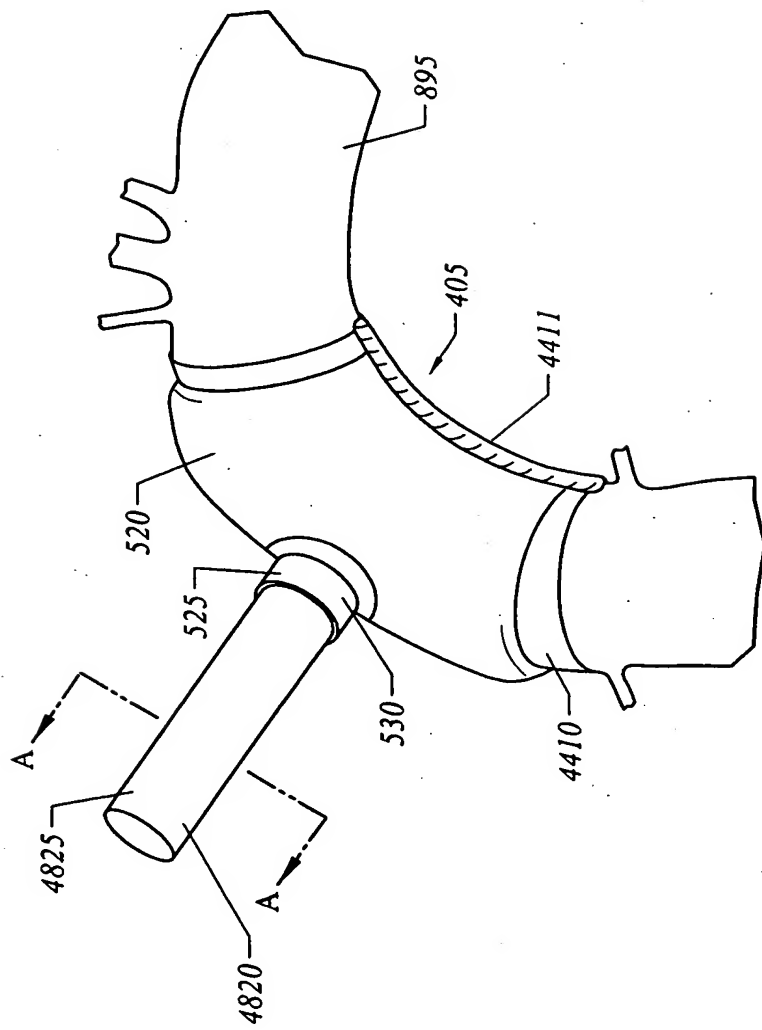


FIG. 48A

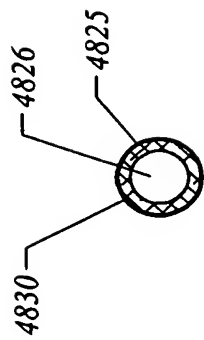


FIG. 48B

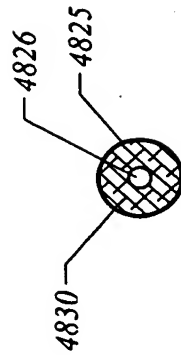


FIG. 48C

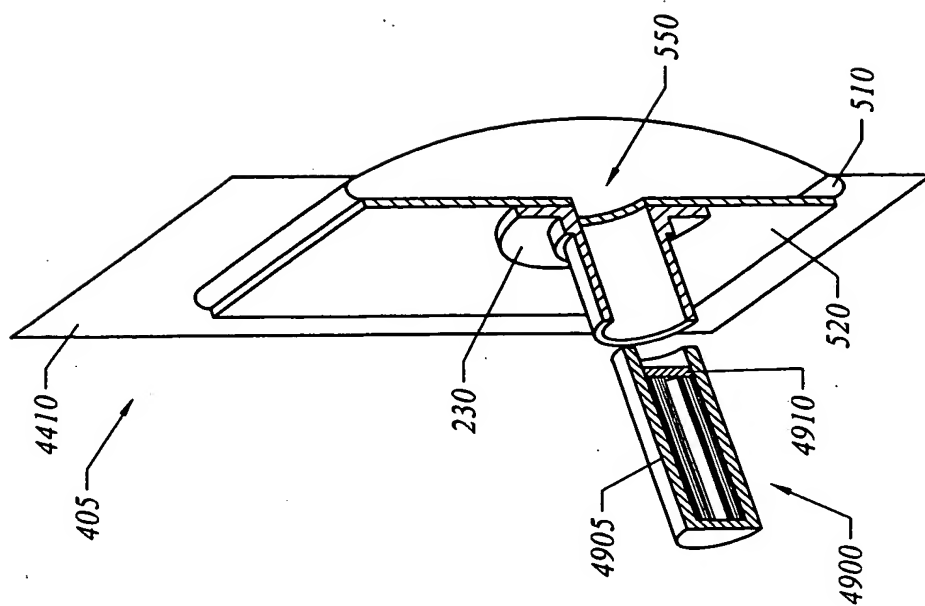


FIG. 49A

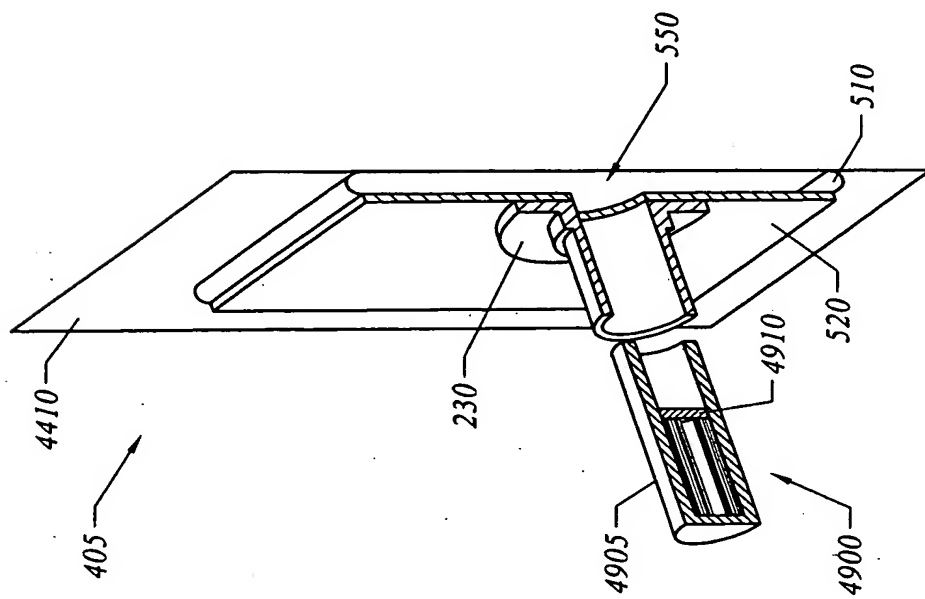


FIG. 49B

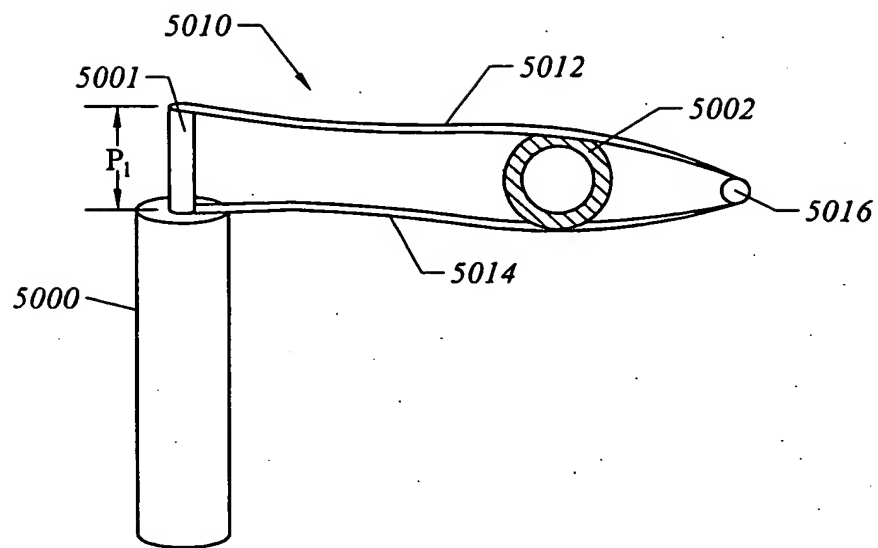


FIG. 50A

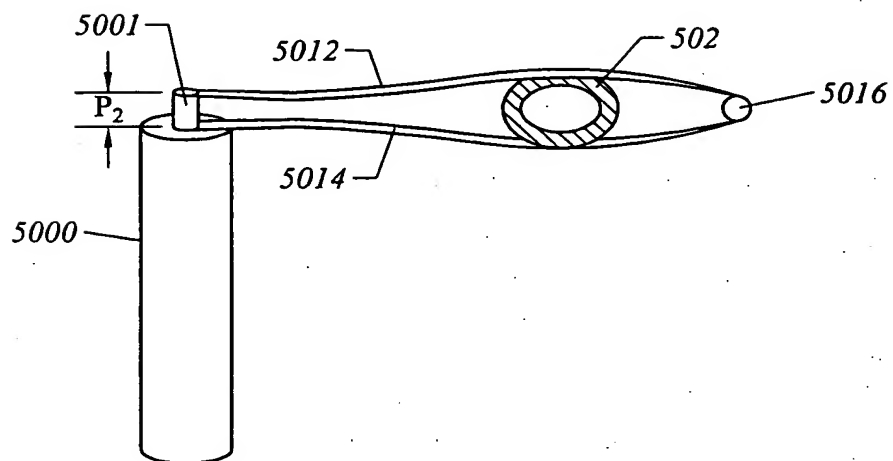


FIG. 50B

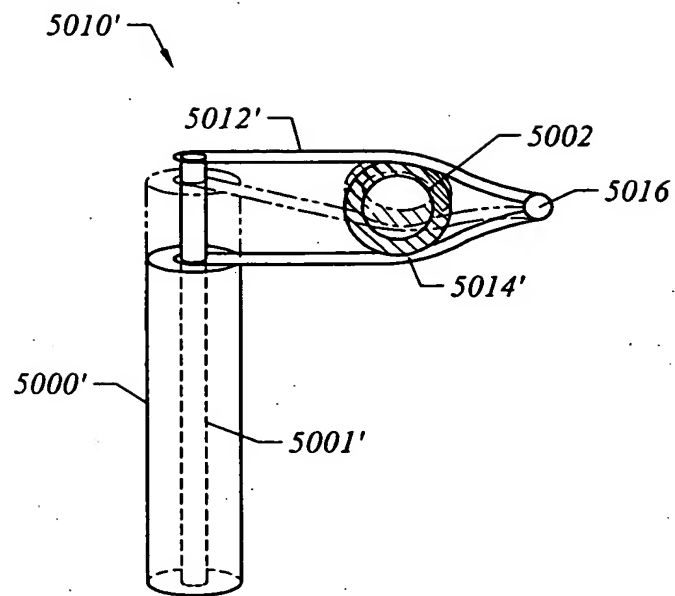


FIG. 50C

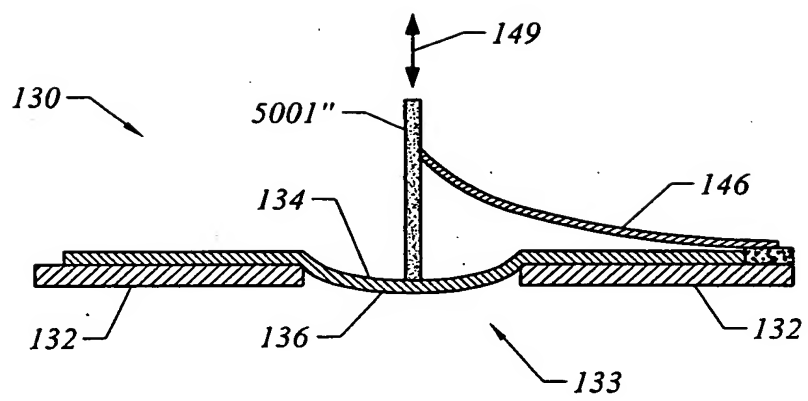


FIG. 51

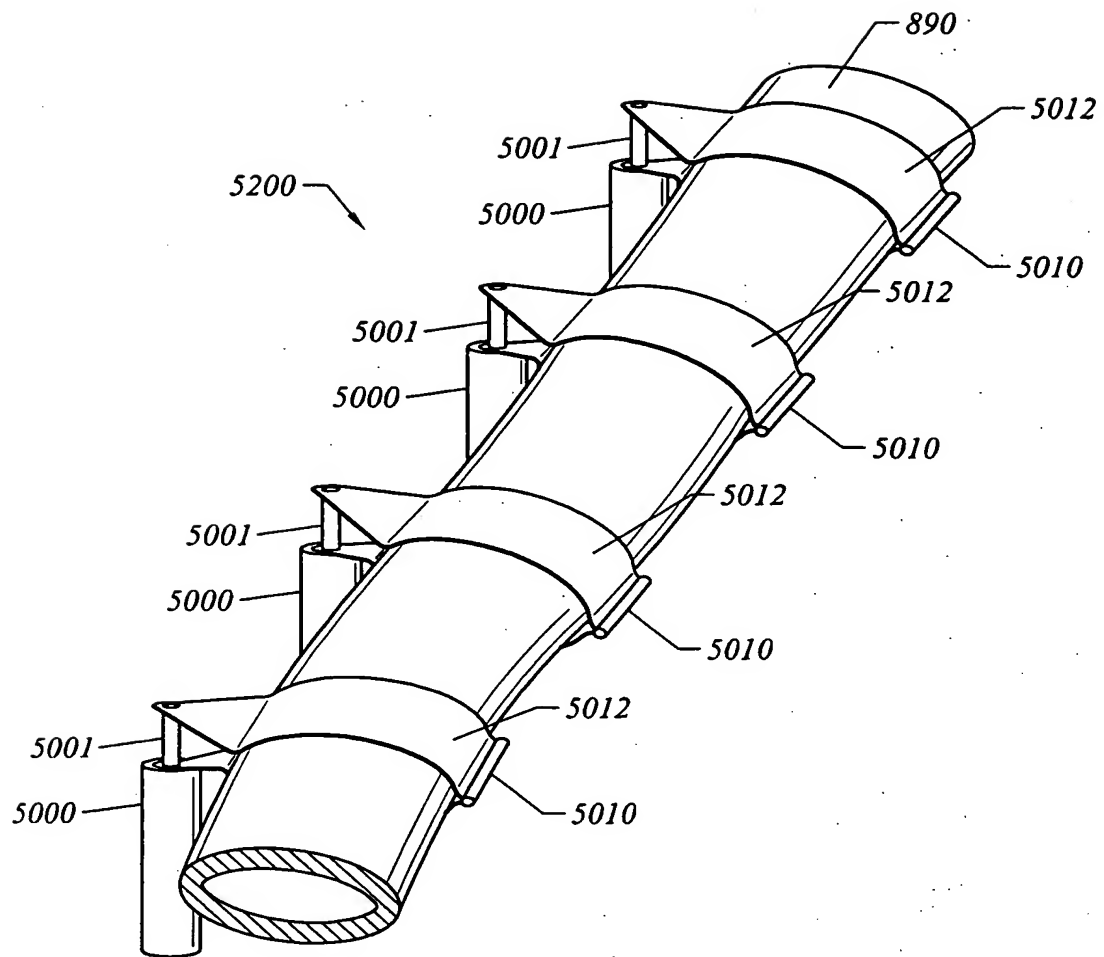


FIG. 52

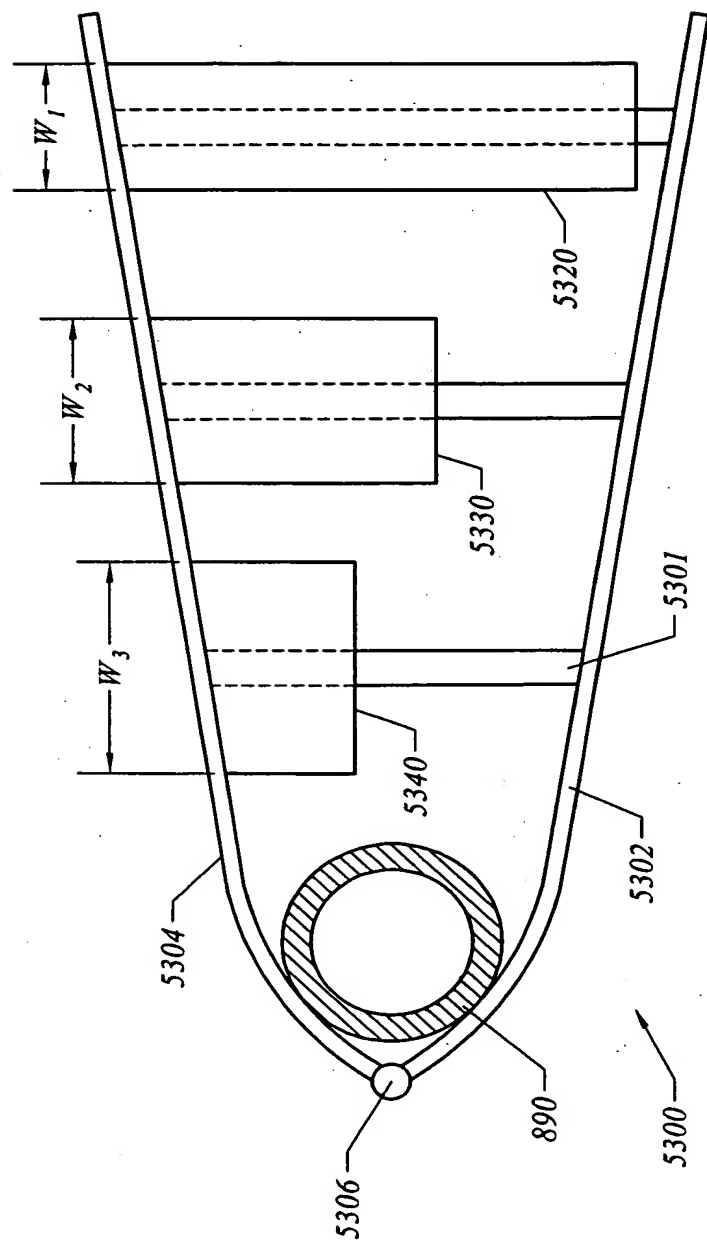


FIG. 53



FIG. 54

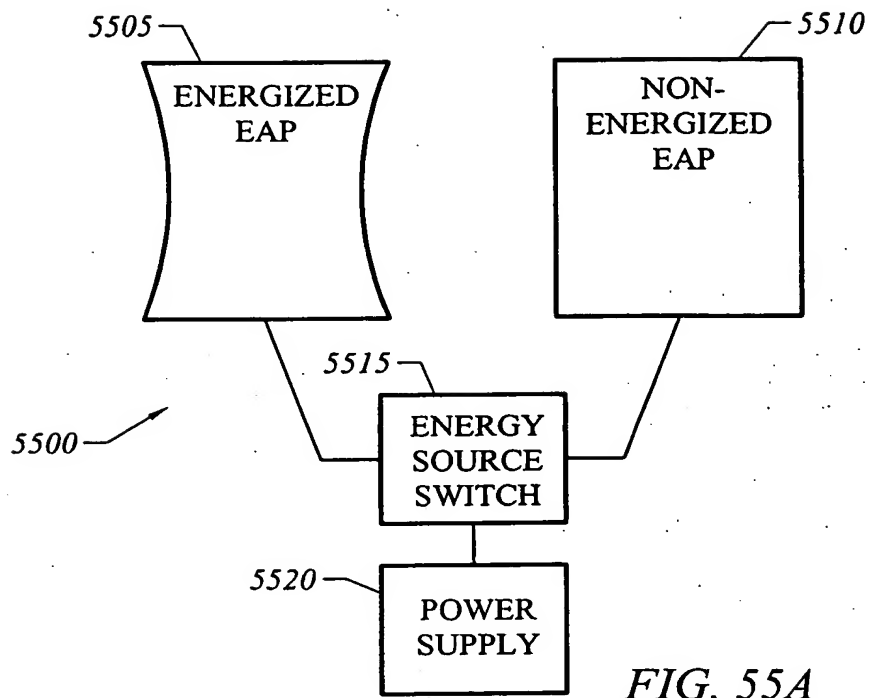


FIG. 55A

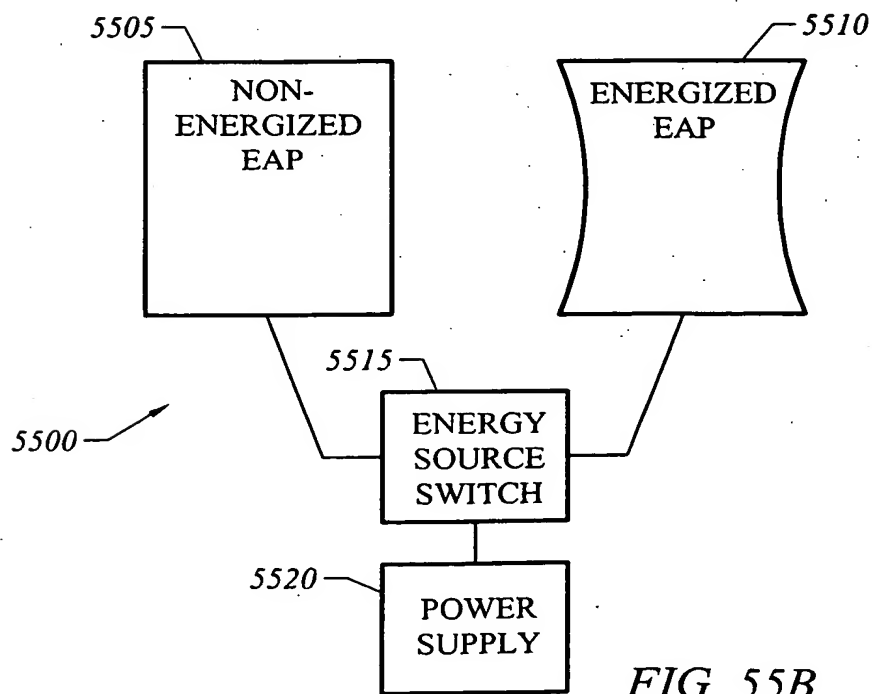


FIG. 55B

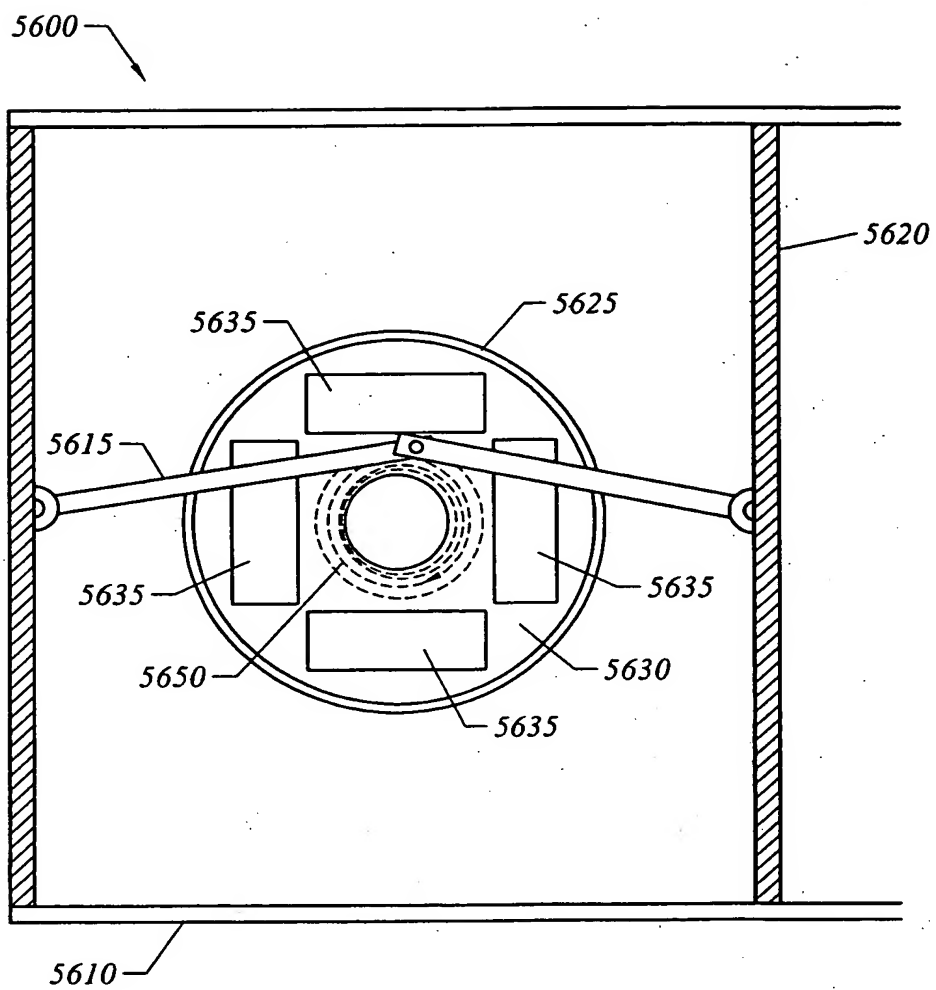


FIG. 56

Comparison of Assist Device Technologies

Description	Screw	Solenoid	Impeller	EAP
Flow	Pulsatile/Continuous	Pulsatile	Continuous	Pulsatile/Continuous
No. of moving components	Many	Many	Many	One (i.e. EAP layer)
Compliance chamber or exhaust	Required	Required	Not Required	Not required
Effects on blood cells	Safe	Safe	Lysis	Safe
Power required	15 to 30 Watts	20 to 45 Watts	8 to 12 Watts	3 to 5 Watts
Efficiency	≤30%	30 to 40%	≈50%	≥80%
Noise	Moderate	Loud	Moderate	Silent

Table C

FIG. 57

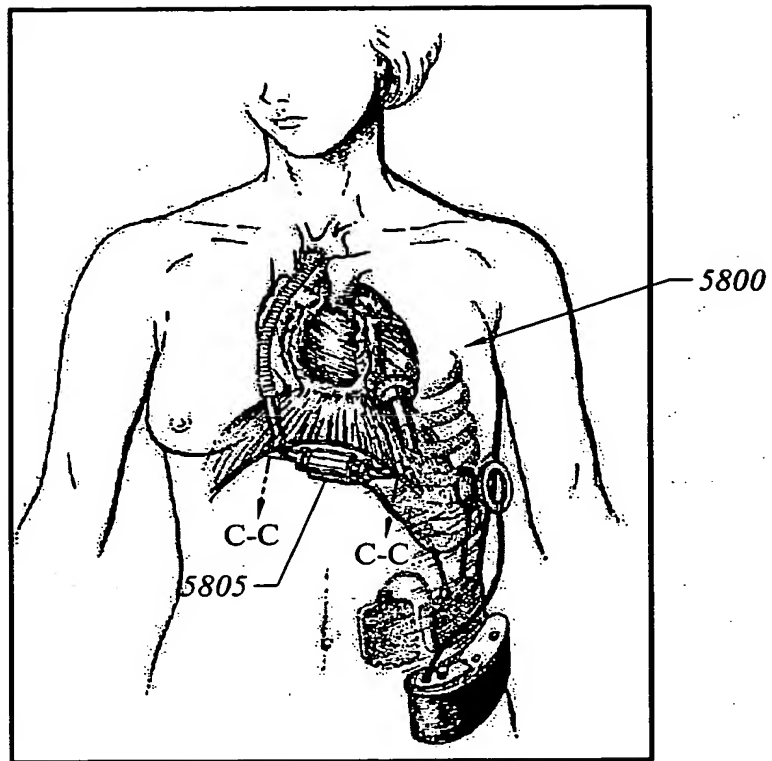
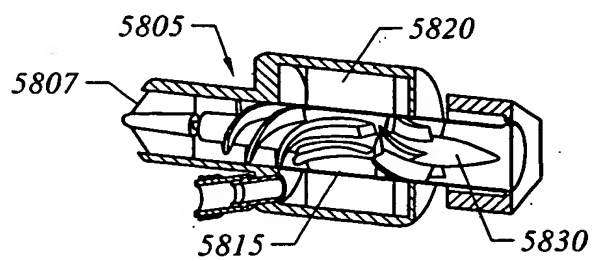


FIG. 58A



Section C-C

FIG. 58B

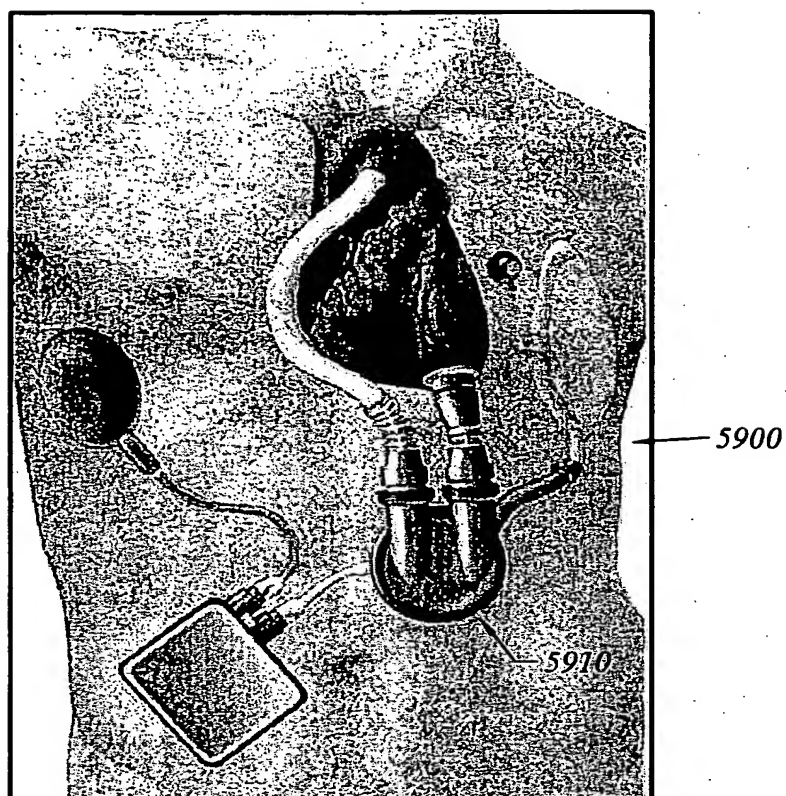


FIG. 59

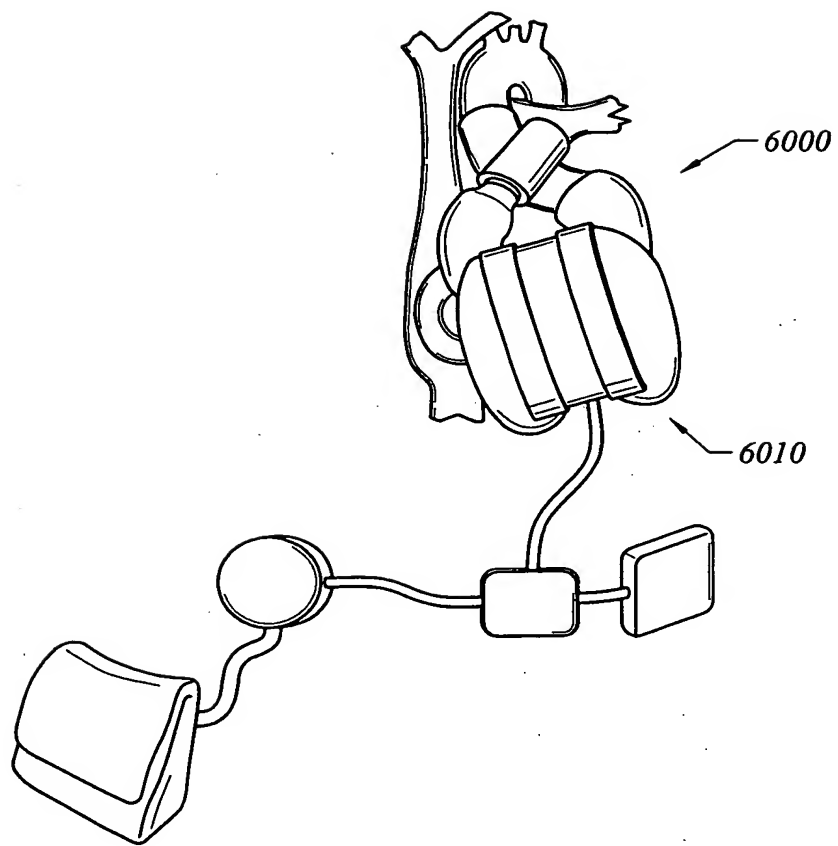
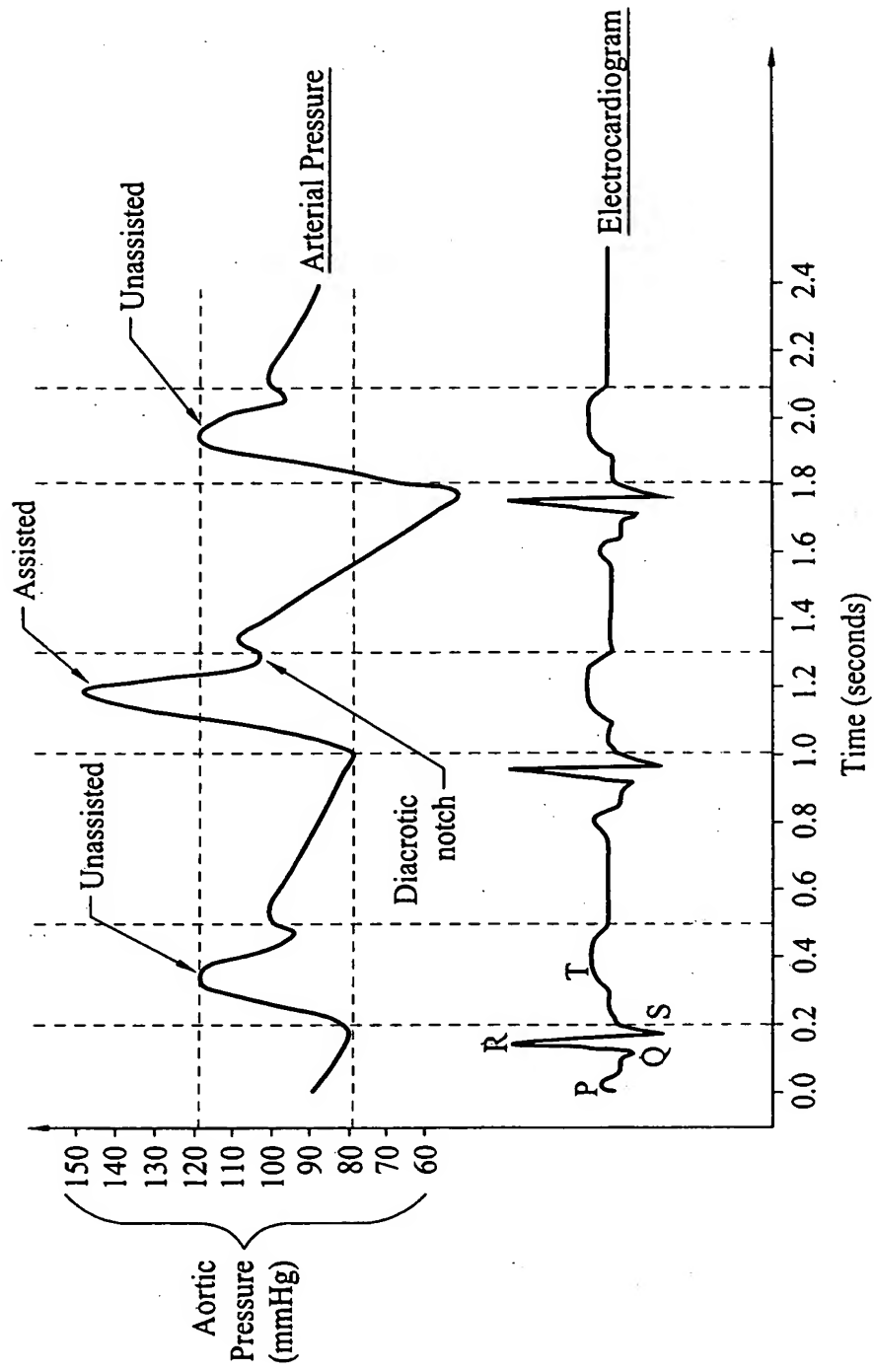


FIG. 60



Copulation

FIG. 61

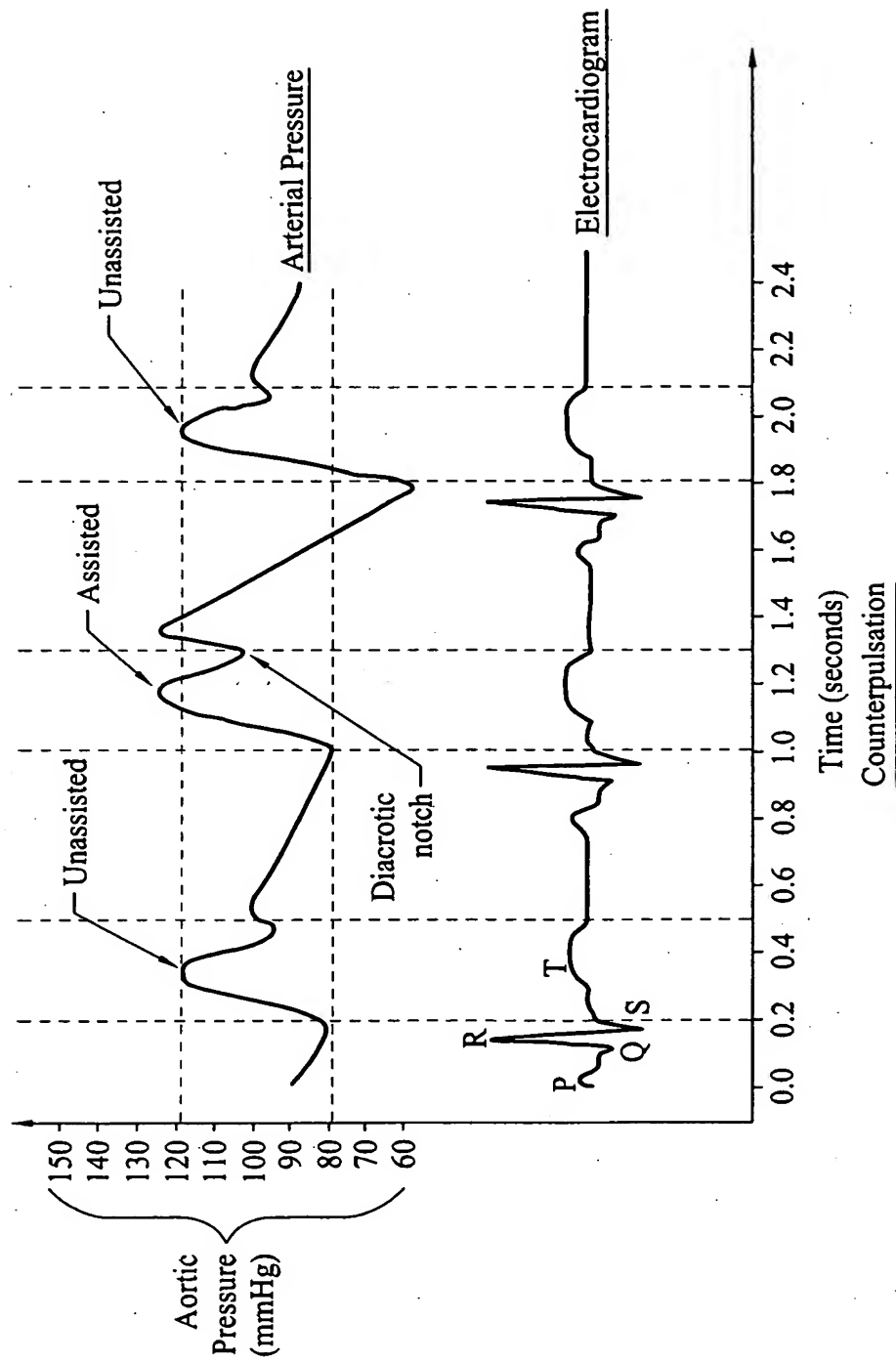


FIG. 62